Governing Urban Development For Local Energy Autonomy

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To my family

Zusammenfassung der Dissertation

Unabhängigkeit in der Energieversorgung, gegründet auf erneuerbare Energieträger, ist zu einem wichtigen Ziel für Gemeinden weltweit geworden. Eine Reihe von Kommunen hat entweder durch Strategien der Energieautonomie die Selbstversorgung bereits erreicht oder die Verfolgung dieses Ziels im Rahmen ihrer Planungen festgelegt. Damit wird ein wichtiger Präzedenzfall für andere geschaffen, ebenfalls die Umwandlung ihres Energiesystems von einem konventionellen auf ein auf erneuerbare Energieträger vor Ort gestütztes in Betracht zu ziehen. Während Energiemodelle rein rechnerisch die technische Kapazität eines lokalen Gebietes zur Selbstversorgung ermitteln und bestimmen können, konzentriert sich diese Dissertation auf die Fähigkeit, Selbstversorgung durch die Steuerung kommunaler Entwicklung hin zu lokaler Energieautonomie tatsächlich zu realisieren. Dafür gilt es nicht nur Strategien und Werkzeuge in den Blick zu nehmen, sondern auch die Handlungsabläufe bei der Verfolgung dessen, was in erster Linie ein Leitbild darstellt.

Seit 1977 hat sich das Fürstentum Liechtenstein offiziell mit der Planung einer nationalen und lokalen Energieversorgung beschäftigt. Im Zuge der stetig wachsenden Bevölkerung und Industrialisierung hat sich das Land immer mehr auf fossile und nukleare Energiequellen gestützt: aus dem Ausland eingeführt machen sie 90 Prozent des primären Energieverbrauchs aus. Auf der lokalen Ebene unternehmen die Kommunen auf Grundlage des schweizerischen Programms Energiestadt fortgesetzt Anstrengungen auf dem Gebiet der Effizienz und erneuerbarer Energien. Einige Kommunen haben ihre Bereitschaft angezeigt, ehrgeizigere Ziele zu verfolgen. Unterdessen haben die jüngsten Ergebnisse aus den Forschungsprojekten Erneuerbares Liechtenstein und zur Bodenseeregion belegt, dass Energieautonomie für das Fürstentum Liechtenstein erreichbar ist, aber in den Ergebnissen wurden nur technische Maßnahmen in der Erreichung dieses Ziels berücksichigt. Um jedoch die Kapazität lokaler Gemeinden zu ermitteln, Energieautonomie mittels der Steuerung kommunaler Entwicklung zu verfolgen, verwendete diese Dissertation einen Bewertungsrahmen für Energieautonomie, der sich auf die Durchsicht von Gesetzgebung und Strategien und auf drei Workshops mit Entscheidungsträgern stützt.

Der Bewertungsrahmen für lokale Energieautonomie wurde auf Grundlage von Expertenbefragungen und Fallstudien entwickelt. Der endgültige Bewertungsrahmen umfasste sechs zentrale Faktoren: lokale Regierungsführung, Bewusstsein für Aspekte und Potenziale der Energieautonomie, Ermessensspielraum kommunaler Behörden, Energiepotenzialmodelle, organisatorische Veränderung und Ausbau sowie die Rolle der nationalen Regierung. Dies ist kein technischer Bewertungsrahmen, sondern einer, der Energieautonomie als einen umfassenden Prozess, der Bildung, Wirtschaft, Umwelt, Politik und Menschen umspannt, betrachtet. Sowohl das Fürstentum Liechtenstein als auch die Gemeinde Balzers untersuchend, lieferte er mehrere wichtige Ergebnisse.

Es stellte sich heraus, dass die Kommunen eine gewisse Kapazität für Energieautonomie besitzen. Doch die Dominanz der staatlichen Energieversorger und der nationalen Energiebehörde, die Vermeidung sowohl von Wettbewerb als auch von Partnerschaften sowie die geringe Transparenz im Austausch kommunaler Energiedaten stellten erhebliche Einschränkungen dar. Tiefgreifende organisatorische Veränderungen wurden für die Verfolgung der Vision auf lokaler Ebene nicht für notwendig befunden, aber als grundlegend werden die Einbindung und Zusammenarbeit mit der breiteren Bevölkerung, gesteigertes Bewusstsein bei den gewählten Gemeinderäten und die Führungskraft des Bürgermeisters erachtet.

Eine koordinierende Stelle oder Taskforce auf nationaler Ebene wird langfristig gesehen entscheidend sein für die Operationalisierung von größeren Projekten, die notwendig sind, um das Ziel der Energieautonomie zu erreichen. Es wurden auch bestehende Leistungsrahmen ermittelt, die ausgezeichnete Voraussetzungen besitzen, um bei der Verfolgung der Vision umgewandelt zu werden. Raumplanung wird eine wichtige Rolle bei der Organisation und Priorisierung von Projekten spielen. Änderungen in Mandat und Recht werden erforderlich werden, um die lokalen

Energieversorger zu einer förderlichen Zusammenarbeit mit den Kommunalbehörden zu verpflichten, um die Raumplanung durch Einbau neuer energetischer Regelungen, die in örtliche Vorschriften einfließen, zu überarbeiten und um Anreize für die Kommunen zu schaffen, miteinander zu kooperieren. Die Normalisierung der Energieautonomie als Leitbild kann erreicht werden, indem auf bestehende Rechtsvorschriften aufgebaut wird, die die Gemeindeautonomie hochhalten, indem die Kontinuität der Projektumsetzung auf unterschiedlichen Ebenen aufrechterhalten wird und indem die Interessen der Stakeholder aufeinander abgestimmt werden, um partizipative Arbeitsgruppen in lokalen Versorgungsnetzwerken zu bilden. Schließlich wird es sinnvoll sein, um das Streben nach der Vision aufrecht zu erhalten, Energieautonomie als Teil der lokalen und nationalen Identität durch Anknüpfung an die lokale Tradition der Unabhängigkeit und Selbstbestimmung und auf nationaler Ebene durch internationale Verantwortung und globale Verpflichtung hochzuhalten.

Übersetzung: Martina Blum

Dissertation Abstract

Energy independence based on renewable resources has become an important goal for communities around the world. A number of local governments have either achieved such self-sufficiency based on energy autonomy strategies or are pursuing the goal as a determined planning target. This sets an important precedent for others to also consider transforming their conventional energy systems to one based on local renewable energy. While energy models can determine a local area's technical capacity for numerical self-sufficiency, this dissertation focuses on the ability to actually realise it by governing urban development for local energy autonomy. The process focuses not only on policies and tools but also on the operations in the pursuit of what is first and foremost a guiding vision.

Since 1977, the Principality of Liechtenstein has formally engaged in the planning of the national and local energy supply. In the process of steady population growth and industrialisation it has come to rely almost entirely on fossil and nuclear energy: as imports these make up 90 percent of its primary energy use. At the local level, municipalities maintain efforts in efficiency and renewable energy based on the Swiss Energy City framework. Some local authorities have indicated that they are willing to pursue more ambitious goals. Meanwhile, recent results from the Renewable Liechtenstein and wider Lake Constance research projects have shown that energy autonomy is achieveable by the Principality, but results were only supported by technical measures of achieving this. In order to determine the capacity for local governments to pursue energy autonomy through the governance of urban development, this dissertation employed an energy autonomy evaluation framework that was supported by reviews of legislation and strategies, and three decision-makers workshops.

The local energy autonomy evaluation framework was developed based on expert surveys and case analyses. The final framework comprised of six main factors: local government leadership, awareness of energy autonomy issues and potentials, local government discretion, energy potentials models, organisational change and augmentation, and the role of the national government. This is not a technical framework but one that looks at energy autonomy as a comprehensive process that encompasses education, economy, environment, politics and people. Used to analyse both the Principality of Liechtenstein and its municipality of Balzers, it yielded several important findings.

It was found that the local governments possessed a certain capacity for energy autonomy. However, the dominance of the national utilities and the national energy office, the avoidance of competition and yet also of partnerships, and little transparency in the sharing of municipal energy data presented severe limitations. Drastic organizational change was found not to be necessary to pursue the vision at the local level, however, the engagement and coordination frameworks with the wider community, enhanced awareness of elected councillors, and mayoral leadership will be essential.

A coordinating body or taskforce at the national level will be critical in the long-term for the operationalisation of larger-scale projects necessary to reach the energy autonomy target. Existing performance frameworks were also identified as an ideal basis for being transformed in pursuit of this vision. Spatial planning will play an important role in organising and prioritising projects. Changes in mandate and legislation will be necessary to commit local utilities to a supportive engagement with the municipalities, revise spatial planning to incorporate new energetic rules that inform local codes, and create incentives for municipalities to cooperate with one another. The normalisation of energy autonomy as a guiding vision can be achieved by building upon existing legislation upholding municipal autonomy, maintaining continuity of project implementation at a variety of scales, and matching stakeholder interests to form participatory working groups in local energy supply networks. Finally, upholding energy autonomy as part of the local and national identity will be useful in maintaining the drive towards the vision, enabled by tapping into local cultural traditions of independence and self-rule, and of international responsibility and global engagement at the national level.

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Chapter 1. Introduction

Local communities are at the brunt of energy impacts. Ever since the first Club of Rome Report on the Limits to Growth (Meadows, Meadows, Randers & Behrens III, 1972), the first oil crisis of 1973, and the global appreciation of the climate change threat at the UN World Commission on Environment and Development in 1987, global initiatives have been pursued to cope with these. The process of rolling conferences have included the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, the first of now more than twenty such annual 'Rio plus N' or 'Earth Summits', and the United Nations Framework Convention on Climate Change (UNFCCC) that commenced with its first Conference of the Parties (COP 1) in 1995 in Berlin, now at COP 19 in Warsaw, Poland. But with every new 'Rio plus' conference and every new COP the goal of concerted action seems further away: global conferences have not had a measurable global effect in its binding agreements. Despite this, in leading to the central focus of this dissertation, they did have a powerful impact on helping to trigger and reinforce important local action - the very 'local agenda' the first Earth Summit in Rio de Janeiro intended, yet never brought to global agreement.

Meanwhile, local authorities are pursuing their own sustainable development agendas at a rapidly increasing pace, in particular seeking to reduce energy consumption and increase the share of renewable energy sources (RES). In Europe alone, evidence of this lies in the growing number of associations that support and network towns, cities and regions in pursuing such goals, such as the International Council for Local Environmental Initiatives European Division (ICLEI-Europe), the Climate Ailiance (Klimabuendnis), the RES Champion League, the Energy Cities through the Covenant of Mayors programme, the European Commission (EC) through the Intelligent Energy-Europe (IEE) programme, the European Green Cities Network and the European Green Capital Initiative. Common to all has been the principled recognition that local governments are central to local energy security. They are key to the transformation of local energy systems and services by setting signals in leadership with community sectors, and functioning as drivers and interpreters of national and international climate and energy goals. Converting such goals into principled action has meant the creation of publicly accessible platforms that offers a range of resources in the form of technical and financial know-how, networking opportunities and award structures - services not otherwise specifically provided by regional, state or national governments. Indeed, the rise of such initiatives at the European level immediately reflects the inadequacies in existing centralised support structures of individual countries (Droege, 2009), and the degree of authority and independence afforded to local governments to enact a range of initiatives on their own accord (Lawrence, 2002). As a consequence, local authorities are seeking help from other parties elsewhere.

With a lack of focused support and leadership from state and national levels, combined with next to no control, or even say, over energy generation or distribution, many local authorities today are left with only a meagre set of permissible and financeable measures to implement advanced local energy measures. A base set of measures would generally comprise: renovating public buildings as best practice examples in energy efficiency and renewable energy, amending building codes with mandatory requirements in energy efficiencies in all new or existing buildings (usually focusing on municipal assets alone), integrating renewable energy technology by all sectors through promotion and incentives, or improving mobility planning measures that regulate public transport, fuel sources, vehicle types, and improved road, pedestrian and cycle ways. However, many local authorities today are acknowledging that more can be done. The turn to European local authority ‘support groups’ described earlier attest to this. As the level “closest to the people” (United Nations Environment Programme [UNEP], 2013), local authorities are receiving requests and support from their own communities to initiate more localised energy projects. They are confronted with advice from independent energy experts to consider implementing a range of measures, from energy consumption and emissions calculations, renewable energy potentials modelling, local energy concept development, to more advanced measures such as the development of solar photovoltaic arrays, local decentralised energy plants or district heating networks. They are also commonly approached by research institutions for the trial, development and monitoring of the latest renewable energy technologies and systems in their locality (Droege, 2009). Many even receive enquiries by interested companies about the availability of renewable energy to power their businesses. Despite the wealth of information and opportunity, it is difficult to gauge whether these consultations have actually translated into real action. The local authority's willingness, capacity and existing modes of practice, critical to manage such projects in the long-run, still remain undisputed factors to implementation.

The interest in local sustainable energy over the last 40 years has largely been driven by environmental, economic and security concerns at the local level (Droege, 2009). As an intrinsic component of sustainable development, its significance has peaked at regular intervals following fossil- and nuclear fuel-induced environmental disasters. Notable events have included the 1979 Three Mile Island and the 1986 Chernobyl nuclear accidents, the 1989 Exxon Valdez tanker oil spill, the 1991 Persian Gulf War oil fires, the 2008 world food, fuel and financial crises, the 2010 BP Deepwater Horizon oil rig explosion and the 2011 Japan earthquake- and tsunami- affected nuclear reactor accidents, to name a few (International Institute for Sustainable Development [IISD], 2012). Such catastrophic environmental impacts serving to not only reflect the danger and futility in relying on fossil fuels and nuclear energy, but to raise the significance of local renewable energy sources as a safe, secure and healthy alternative.

One such significant paradigm shift for local authorities has been the pursuit of energy autonomy, a state at which local energy self-sufficiency is achieved through the optimisation of energy efficiency alongside the complete replacement of local fossil energy use with locally supplied RES. Akin to the concept of energy autarky, the energy autonomy vision has received much attention to date within the fields of urban, rural and regional sustainable development (Späth & Rohracher, 2010; Girardet & Mendonça, 2009; Carlisle & Bush, 2009; Wuppertal Institute, 2009; Weidner & Metz, 2008; Scheer, 2007; Droege, 2006, 2009). It has entered sustainable development discourse and pervaded policy statements of many governmental and non-governmental groups. It has even become the basis of operations for those groups particularly engaged in the monitoring of municipalities and regions that have either attained or are moving towards local energy self-sufficiency (Climate Alliance, 2012; International Network for Sustainable Energy [INFORSE], n.d.; International Commission for the Protection of the Alps [CIPRA], 2010a; Droege, Radzi, Carlisle & Lechtenböhmer, 2010; Institut dezentrale Energietechnologien [IdE], 2014).

1.1 Context

With the above issues in mind, this dissertation explores how local governments can effectively govern urban development to achieve local energy autonomy, by using the Principality of Liechtenstein and one of its municipalities – Balzers – as test cases. Three research programs form the basis of this exploration: The Lake Constance - Alpine Rhine Valley Energy Region (Bodensee-Alpenrhein Energieregion - BAER) research project, the Renewable Liechtenstein (Erneuerbare Liechtenstein – EL) research project and the Space Type Energy Model (STEM).

1.1.1 Lake Constance Alpine Rhine Valley Energy Region BAER

The BAER research program operated between 2009 and 2013, broadly focused on the mitigation of climate change and energy risks in a large international region. An initiative by the lead institution, the University of Liechtenstein (Liechtenstein), partners included the University of St. Gallen (Switzerland), the University of Technology, Economics and Design Constance (Germany), the Technical University of Rapperswil (Switzerland), and Zurich University of Applied Sciences and Technology Winterthur (Switerland). The project was supported by the International Lake Constance University (Internationale Bodensee-Hochschule - IBH) and the European Commission's Interreg Program, which encourages inter-regional cooperation.

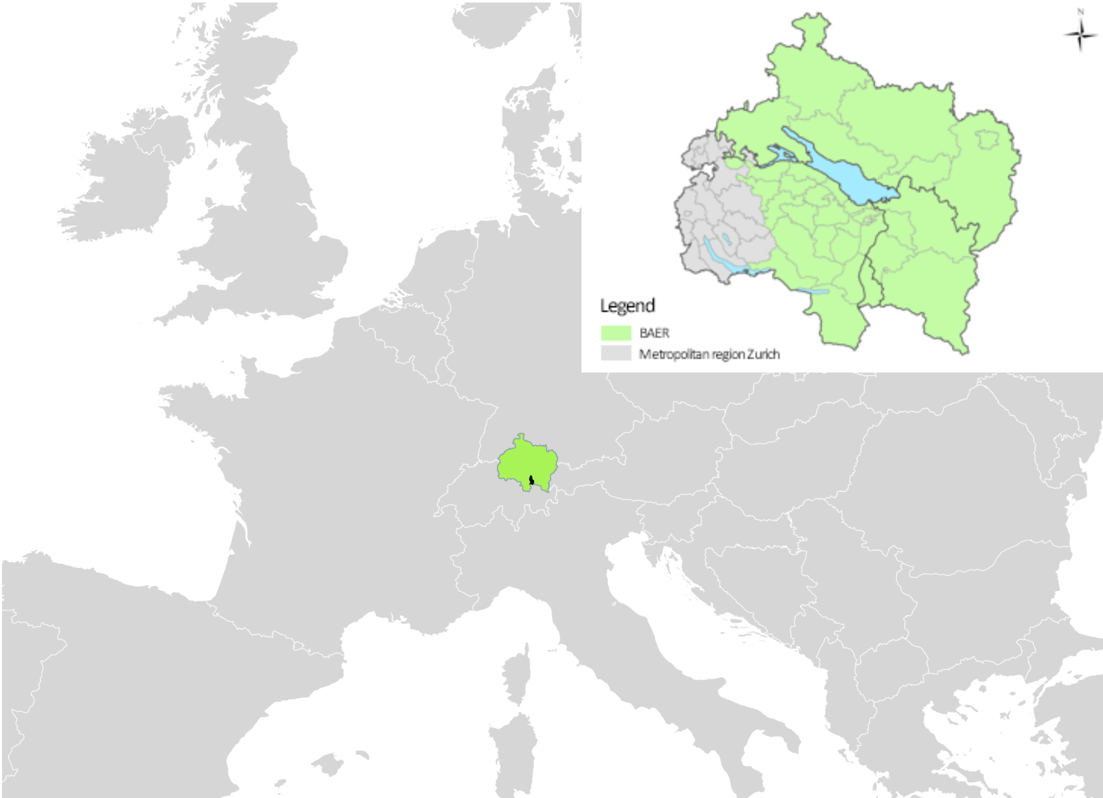

Fig. 1. The location of BAER within the IBH-IBK region in Central Europe (Droege, 2014; http://www.wikimedia.com).

The BAER study area covers a large part of the Lake Constance region - the domain of the International Lake Constance Conference area. This International Lake Constance Conference (Internationale Bodensee Konferenz - IBK) is an alliance of adjoining states of four neighbouring countries, and was founded in 1971 in part to protect the environment and waters of Lake Constance, a remnant glacial water body in Central Europe stemming from the last Ice Age. The IBK forms the umbrella organisation of the IBH, a network of 30 universities and other institutions of higher learning, actively engaged countries, states, provinces and cantons adjoining Lake Constance region (See Figure 1). The IBH – IBK Lake Constance region covers a total land area of 14797 km^2 and consists of several Swiss cantons, a number of German rural districts, the Austrian state of Vorarlberg and the Principality of Liechtenstein. In 2009, the region's population was approximately 3.8 million, with the highest population density found in urban areas. There are 366 local governments operating within the region. The IBK addresses solutions for regional challenges through the encouragement of cross-border cooperation.

The BAER area is identical to the IBH - IBK Lake Constance Region, but excludes the densely built-up portion of the greater Zurich region, the *Metropolregion Zurich* comprised of the cantons of Zurich and Schaffhausen, about 2000 km^2 in area (Droege et al., 2014) (See Figure 1 insert).

The BAER research program focused on five specific themes: resilient urbanism, energy efficiency of buildings and settlements, integration of solar systems and other equipment for the supply of renewable energy in buildings and settlements, sustainable mobility including the development and promotion of electric cars and solar stations, and the improvement of market opportunities for renewable energies.

Central to the work of the resilient urbanism group was the idea that the region should be able to meet its own direct stationary and mobile energy needs sourced from a diverse set of wholly local renewable resources (sun, wind, water, geothermal and biomass). Energy independence is expected to strengthen the region's ability to withstand negative market and economic forces such as increasing fossil fuel prices, and mitigate energy inequality, inaccessibility and poverty; but also reinforce its ability to more actively counter climate change, or reduce its impacts. A diversity in available local energy and other resources renders a region more resilient to multiple economic, social and environmental pressures - the very concept of local energy security that motivates a number of communities - and no longer only those in the Transition Towns movement, borne of the hope to guard against Peak Oil.

As member of the resilient urbanism workgroup, the author's primary goal was to understand whether the existing urban and regional development structures in the region had the capacity to pursue regional energy autonomy in order to become resilient to the effects of future fossil fuel depletion and climate change. Were the current regional strategies in sustainability able to be adapted according to the concept of resilience as the basis for future self-sustaining, non-polluting, even climate-stabilising urban development? Could existing policies be improved or was a synthesis of global approaches adapted to regional concerns a more appropriate action strategy to achieve resilience on the basis of energy autonomy? To answer these questions, a review of the existing literature on resilient urban development and energy autonomy was undertaken to establish the necessary criteria. The institutional frameworks in sustainability and energy within the region were then evaluated against these criteria.

The end results showed that despite the presence of various environmental associations and regulatory bodies, goals and policies on energy were either inconsistent or absent in spatial planning. Resilience as a concept did not explicitly figure in any national, regional or local policy within the BAER countries. It was found that the range and discoordination of strategies between bordering municipalities and countries, which possessed very different value systems and priorities would greatly impact the success of any singular regional energy vision such as energy autonomy. Some municipalities were more pro-active in pursuing a range of initiatives in energy while others were largely re-active to higher-level recommendations for essential energy improvements.

The research from the region indicated that partnerships established between the local authorities with influential individuals, residents, businesses, institutions and various independent organizations were best to boost renewable energy production and distribution within different parts of the BAER area. A select few had even become energy autonomous, or had this target in place and were on their way to achieving it. Although national entities were hugely effective to drive state legislation and to act as advisory or promotional bodies of policies on energy efficiency and renewable energy, it was usually left up to the local governments to take real concerted action, which they did so essentially through public-private energy partnerships. Furthermore, it was found that the research and development bodies actively operating within the BAER study area, sometimes operating as partially private companies, were the most successful in translating such visions as energy autonomy into real, concrete actions for local authorities. This is in contrast with the larger trans-national regional associations such as CIPRA, which although had achieved great success in marketing *the success of* sustainable development projects across regions, they were not directly involved in renewable energy implementation, beyond general policy statements and the documentation of best case practices.

1.1.2 Renewable Liechtenstein EL

In 2012, the Renewable Liechtenstein research project concluded that the Principality of Liechtenstein can achieve 100% renewable energy self-sufficiency or in other words, energy autonomy by 2070, provided that several recommended measures are implemented. The finding was the result of assessments carried out between 2009 and 2011 on the energy consumption, renewable energy generation potential and CO_2 equivalent savings of the Principality. The statistics were used to develop scenarios for energy development alongside specific measures for the targeted and meaningful development of renewable energy generation in the Principality, as well as appropriate, effective reduction measures in the area of efficiency and sufficiency.

To assess the ability of the Principality to cover its direct energy demand with renewable energies procured within the country, the study compared the current energy consumption and future consumption projections with the potential for increased efficiency and local renewable energy supply through two major scenarios (Reference and Innovation). The reference scenario assumed the continuation and update of current trends, whereas the innovation scenario assumed advanced efforts to reduce energy consumption, increase efficiencies, and to replace non-renewable energy with locally generated renewable energy. The scenarios were calculated and visualised using a space typological energy model. Energy potentials were graphically expressed through a series of energy potential maps of Liechtenstein for generating on-site heating and electricity, differentiated according to the two scenarios. A detailed explanation of this model can be found in the following Section 1.1.3.

The research project adopted the island-principle, which means that the borders of the Principality formed the extent of the system boundary for analysis. This follows on from the project's objective to prioritise the national capacity for self-sufficiency before proceeding to external energy substitutes. To minimize the direct energy footprint, no direct energy resources were modelled outside the country. The indirect energy consumption, the embodied energy in products and services, - such as food, clothing, vehicles or flights – and was also excluded in this model. The project distinguished between four energy parties: residential, work and mobility, assuming the consumption of energy in the form of heat, hot water, electricity and fuels.

In its final report, the Renewable Liechtenstein research project concluded that the renewable energy self-sufficiency or energy autonomy cannot be achieved based on the progression of current trends. However, if advanced projects in efficiency, sufficiency, renewable energy measures and electric mobility as recommended by the 'Innovation' scenario are employed, the Principality can achieve this goal by 2070. The recommendations include (Droege, Genske, Joedecke, Roos & Ruff, 2012):

1. Energy consumption to be markedly reduced by increasing the efficiency of the systems of energy supply, business and manufacturing through better work practices and equipment replacement. Energetic building renovation and energy-efficient construction through the compliance of strict energy standards to be intensified from the existing rate of 1% to 2%. Efficiency measures in transport sector through public transport and promotion of motor vehicles with low consumption to also be promoted.
2. Sufficiency to be addressed in order to deal with changes in consumer behaviour and lifestyle choices, such as communicating instructions on the economical use of heating, cooling and electricity in the home or saving fuel by using public transport or prioritising local produce.
3. Renewable energy measures to be expanded and integrated into a network structure of decentralized renewable energy inputs, enabled by suitably aligning planning processes and financial incentives such as technology rebates or feed-in tariffs. Roofs, facades and open spaces to be used to increase electricity generation by deploying photovoltaics to about 70 GWh/a by 2050, whereas heating with solar panels to increase by four-to five-fold. Solar surface inventories (roof, parking, road furniture) to better determine localised solar potentials. Large hydro power plant by 50% by 2050 to be expanded, combined with the implementation of water vortex power plants and other ecological projects. Deep geothermal energy for heating is strongly recommended. Due to limited resources of arable land in Liechtenstein, the continued use for agricultural waste products as biomass resources

is encouraged, especially for the production of biogas, rather than the planting of energy crops.

4. Electric mobility to be promoted, through the increased focus on energy research and technology innovation, not just in mobility but also for other renewable energy technologies.

The Renewable Liechtenstein study ended with recommendations for additional studies to help pursue the goal of energy autonomy by the Principality. These included creating solar registers (cadastres) for roofs, parking lots and other transport structures, designing practical frameworks for increasing efficiency and sufficiency, updating potentials calculations and savings, developing soil maps for carbon storage as a means to reduce CO_2, providing overall economic cost or benefit calculations, and developing strategies based on politically, socially and organizationally optimized implementation.

The last recommended study forms the focus of this dissertation. What adjustments are required in the existing planning processes to achieve energy autonomous urban development in Liechtenstein? What trade-offs in decision-making may occur in planning for such development? What is the role of energy models such as STEM in a planning process that pursues energy autonomy?

The findings of the Renewable Liechtenstein study have since been included in the Principality's national Energy Strategy 2020 (Energiestrategie 2020) as one of three potential energy scenarios for achieving the 20, 20, 20 target as set by the European Commission to "reduce greenhouse gas emissions by 20%, raise the share of renewable energy by 20% and make a 20% improvement in energy efficiency" by 2020 (EC, 2011, p. 4). Despite its acknowledgement by the national government, the 100% scenario was not considered the preferred option for the country due to concerns of practicality, cost-effectiveness and the difficulty to influence lifestyle choices (Energy Commission, 2012). However, I argue that such concerns are largely attributed to the lack of awareness of the real benefits of optimising energy efficiency and renewable energies for energy autonomy, the advantages that this dissertation explores.

1.1.3 Space Type Energy Model STEM

In his treatise 'The Wealth of Nations', Scottish philosopher and economist Adam Smith (1723-1790) postulated that production requires the resources of work, and capital (Smith, 1776). In the context of renewable energy production, one can argue that the 'work' is free, that is, the solar energy gained from the sun is without cost and is limitless. In terms of the 'soil' required, urban and rural areas give us the space to implement the technology. In relation to 'capital', investments can cover initial implementation costs and help generate long-term profits. Therefore, the evaluation of surface potentials against the various renewable energy generation options available is key. To assess the economic benefits, the amount of 'soil' or space available needs to be identified and quantified, and the various types of renewable energy generation needs to be assessed according to their different space requirements. Through good land-use planning, such factors can be carefully managed. These principles form the basis of a space type energy model or STEM.

This energy modelling approach was adopted and developed by the Renewable Liechtenstein research project and subsequently further enhanced in the BAER research project, where it was called STEM. This computer energy calculating tool has been previously applied to several Swiss and German model regions, including the city of Basel in Switzerland; and the cities of Stuttgart, Leipzig, Gelsenkirchen, Sondershausen, Hamburg in Germany (Genske et al., 2009). STEM sits within the context of a range of computerised urban energy models that exist as stand-alone models for individual-building or localised community applications, to systems-based models for city-wide, regional or national applications. Examples of stand-alone models include feasibility analyses for new local power plants such as hydropower or biomass CHP (Lee & Shih, 2011; Schmidt, Leduc, Dotzauer & Schmid, 2011), energy consumption calculations of households, villages or historic centres (Gadsden, Rylatt, Lomas & Robinson, 2003), or energy monitoring of local utilities (Henning, 1997). Systems-based applications include renewable energy systems optimisation across technologies or urban sectors (Baños et al., 2011; Pietpertrosa, Cosmi, Macchiato, Marmo & Salvia, 2003), renewable energy potentials modelling of cities (Everding, 2007; Genske, Porsche & Ruff, 2009; Robinson et al., 2007), or 100% renewable energy potential assessments for entire countries (Ćosić et al., 2012; Krajačić, Duić & Carvalho, 2011; Mathiesen, Lund & Connolly, 2012; Mathiesen, Lund & Karlsson, 2011; Connolly, Lund, Mathiesen & Leahy, 2010).

In contrast, STEM uses a geographic information system (GIS) platform to visualise spreadsheet calculations of energy demand, possible efficiency gains, local renewable energy sources, in order to determine the local energy autonomy capacity for various scenarios and time frames. Central to STEM is the mapping of energy potentials according to space type or 'urban prototypes' (Genske et al., 2009). It is based on the principle that every urban area has the potential to optimise its energy efficiency and produce renewable energy, depending on factors such as building type, their density, infrastructure, technological limitations, and site use. The city for example, can be divided into urban space types such as: historic centre, business district, residential area, industrial zone and so forth (Everding, 2007). As a consequence each space type possesses its own energy consumption and production profile according to how the space and buildings are used. Urban space types (UST) are not taken as standard types but can be adapted according to the objectives of the research. Table 1 lists the types that were developed in the Renewable Liechtenstein research project. Table 2 lists the types developed for the BAER research project.

Table 1. Urban space types in Liechtenstein (Droege et al., 2012).

Use		UST
Mixed use	Settlement core	I
	Historical buildings	II
	Multi-family house with commercial	III
	Rural	IV
	New building area	N
Living	High rise	VII
	Multi-family house without commercial	VIII
	One and two family houses	IX
Work	Business and industry	X
	Miscellaneous buildings	X-Z
Transport	Transport areas	XI
Unbuilt areas	Forest	XII
	Agriculture, farm, meadow	XIII
	Unproductive	XIV
	Water	XV
	Others	XVI

Table 2. Urban space and landscape types for the BAER study area (Droege et al., 2014).

Use		UST
Mixed use	Pre-Industrial Old City	I
	Classical foundation	II
	Rural and small-scale structures	IVa
	Multifamily housing with commercial	IVb
Living	Work and cooperative settlements	V
	Social housing estates	VI
	High-rises	VII
	Multi-storey housing	VIII
	One and two-family housing areas	IX
Working	Commercial areas	X
	Non-residential (Miscellaneous)	XI
	Commercial in mix-used area	X-M
Unbuilt areas	Green areas (Meadows, fields, green spaces)	XIIa
	Agriculture/ farmland	XIIb
	Unproductive areas	XIIc
	Forest	XIId
	Transport areas (Road, rail)	XIVa
	Water	XIVb
	Wetlands	XIVc
	Others	XIVd

Further to renewable energy generation, each space type within STEM represents a certain profile for thermal, electricity and fuel demand. By assuming that energy efficiency improvements in the built environment such as replacing windows, repairing roofs and retrofitting facades occur in the long-term at given renewal rates, future energy demands can be projected. The different energy needs of households, businesses, industry and mobility can then be distinguished. In addition, discrete and diffuse energy sources can also be differentiated. A diffuse energy source is energy that is generally available across an area, e.g. solar energy. A discrete energy source is one that requires specific areas or is specific to certain locations e.g. wind and hydropower. The ability to double up on space to enhance the spatial energy performance also becomes a factor in the calculations and scenario formulations.

STEM only considers direct energy and excludes indirect energy. Direct energy is the energy required to meet the needs at or closest to the point of demand, whereas indirect energy is the embodied energy associated with the production, installation, operation, consumption, maintainance, dismantling and disposal of all goods and services including the energy services required. STEM also does not account for the energy efficiency and renewable energy potentials from urban energy infrastructure such as water, sanitation and waste systems. Energy calculations for mobility were in BAER newly introduced along with the calculation of carbon sequestration potentials.

Based on the above factors, STEM can calculate the ratio of renewable energy produced to energy needed for both thermal and electric energy, in order to arrive at degrees of self-sufficiency in supply, or the level of energy autonomy. The outcome is visualized by means of a GIS system. Figure 2 shows the method for deriving maps depicting the potential for renewable energy generation. STEM maps allow comparisons of renewable energy production capacity against energy demand according to different scenarios. Energy deficiencies can be identified and additional concrete supply options can be planned. For the BAER research program and the Renewable Liechtenstein research project, two scenarios were examined: the business-as-usual scenario (‘Reference’ scenario) and the optimised efficiency, sufficiency, and renewability scenario (‘Innovation’ scenario). The later is taken as the energy autonomy model discussed in this dissertation. Figures 3 - 6 illustrate the STEM maps produced for both of the research projects.

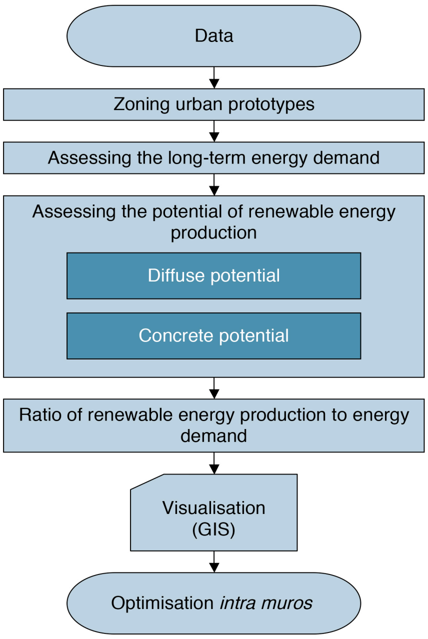

Fig. 2. Methodology behind the space type energy model (Genske et al., 2009).

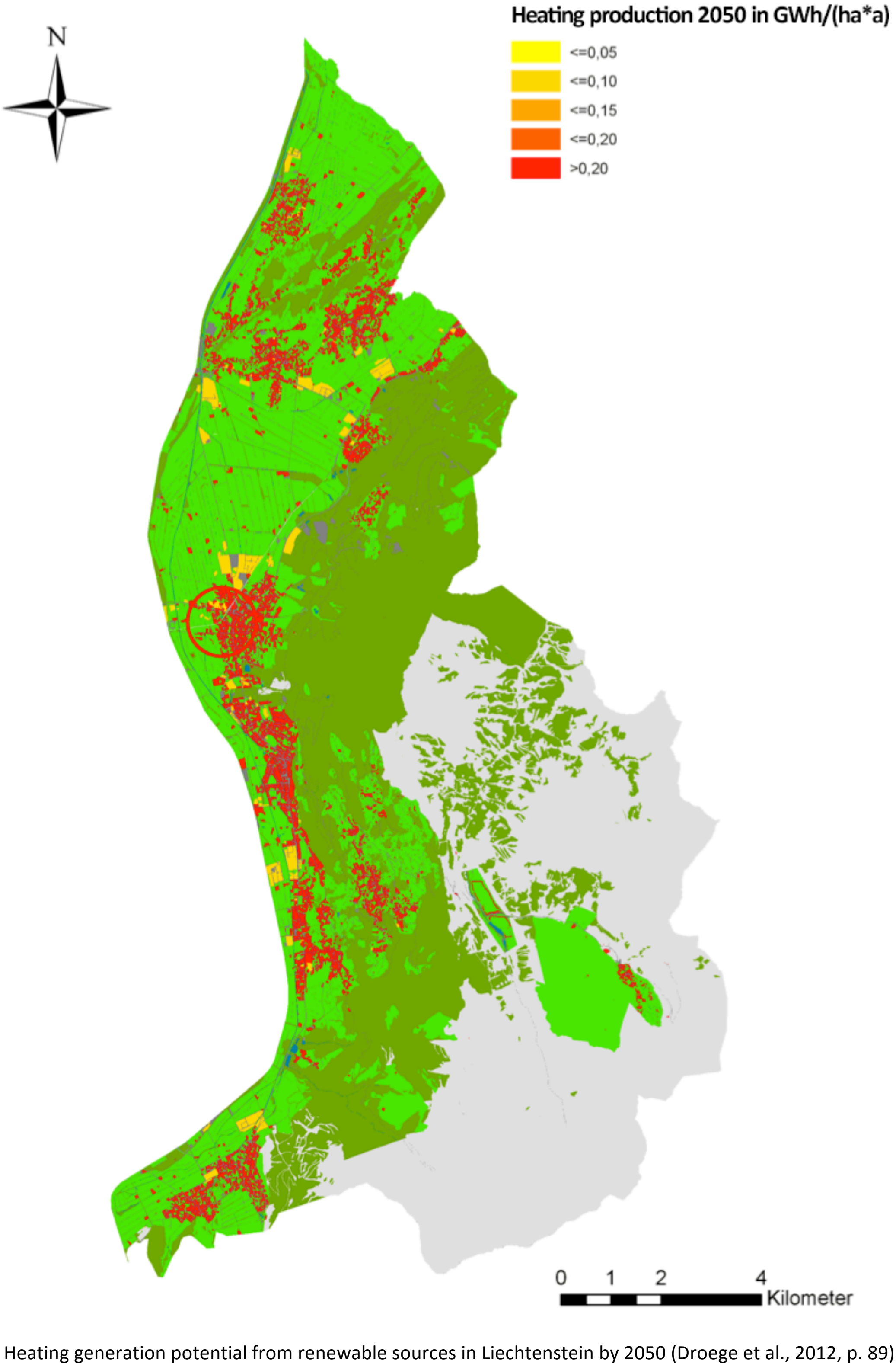

Fig. 3. Heating generation potential from renewable sources in Liechtenstein by 2050 (Droege et al., 2012, p. 89).

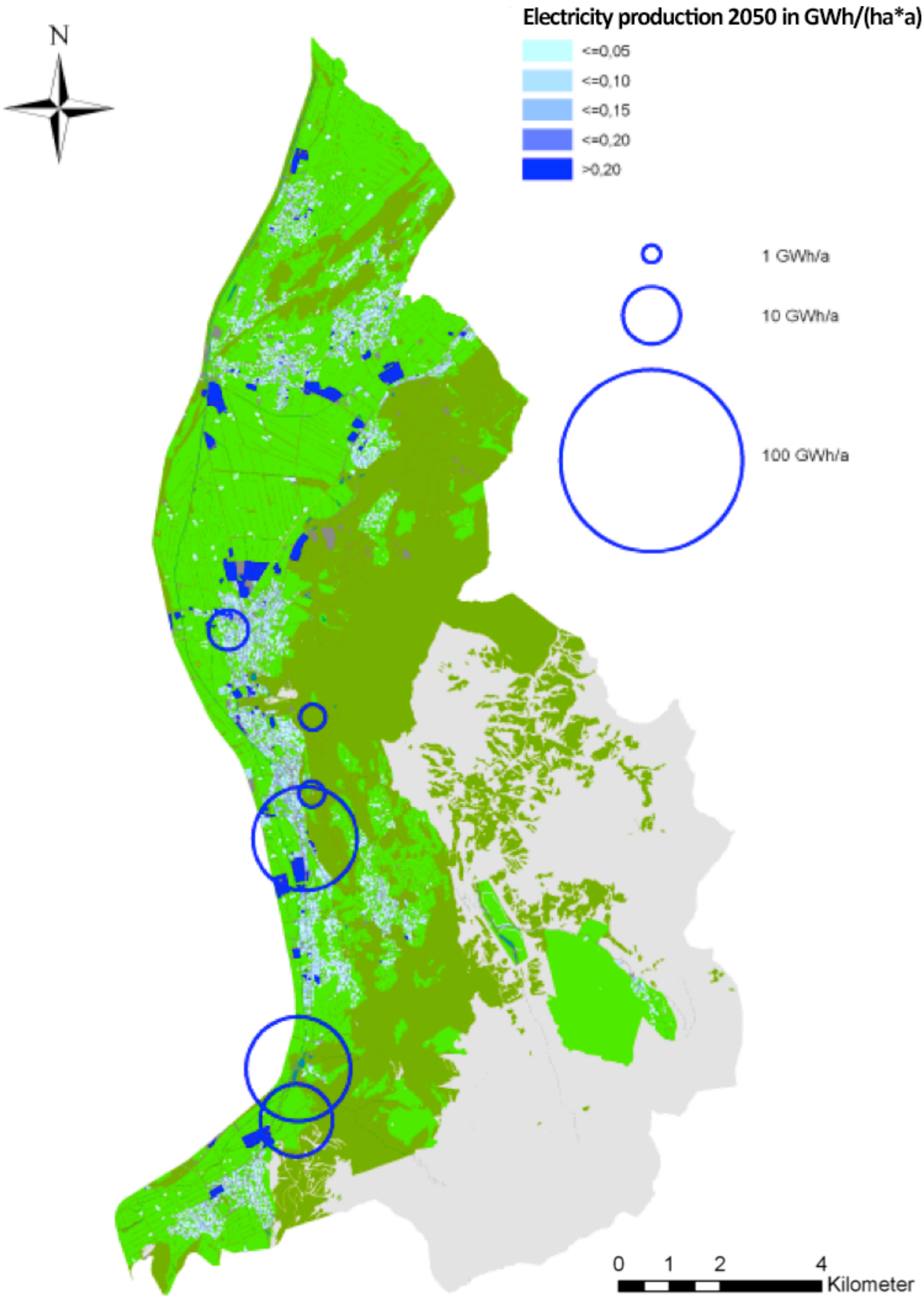

Fig. 4. Electricity generation potential from renewable sources in Liechtenstein by 2050 (Droege et al., 2012, p. 92).

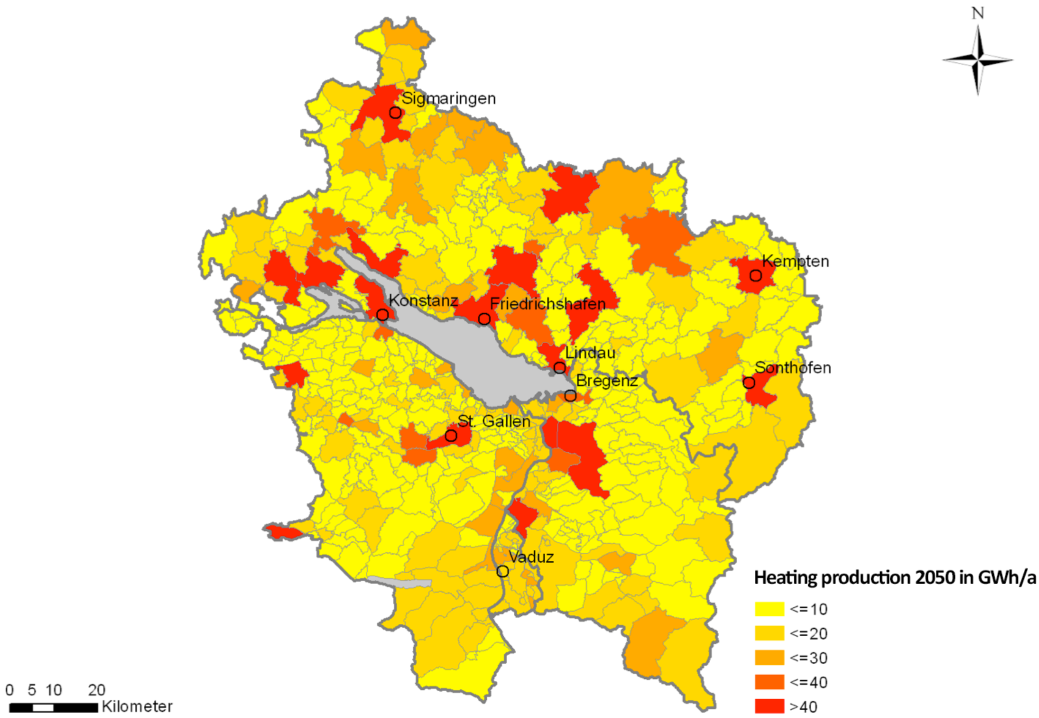

Fig. 5. Heating generation potential from renewable sources in BAER by 2050 (Droege et al., 2014).

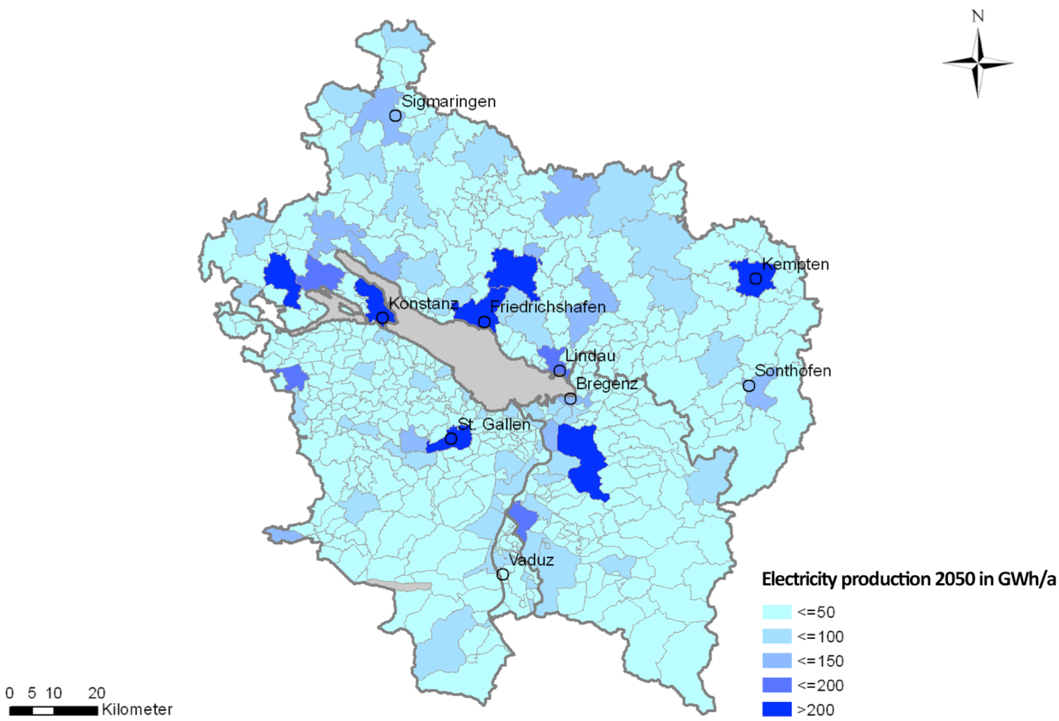

Fig. 6. Electricity generation potential from renewable sources in BAER by 2050 (Droege et al., 2014).

STEM is founded on the calculational principle that energy demand should only be met by renewable energy produced within the local government, state or national area in which the demand was created, in other word *intra muros* or *within the walls*. The emphasis is on decentralized renewable energy that avoids using external resources, external space, and the emissions of greenhouse gases. Although this dissertation accepts the prioritisation of locally generated energy before external energy resources, the principle of self-sufficient islands is not considered as the only or absolute criterion for pursuing energy autonomy.

STEM is more than a local energy calculational tool. It tests the practical feasibility of local or regional energy autonomy *intra muros* along given or assumed future scenarios - without considering embodied or imported energy for lifestyle dependent consumpion of goods and services. It is a scenario based projection, not a trend forecasting method. STEM's two default scenarios - a 'reference' (based on current best practice projected forward) and an 'excellence' scenario (based on performance criteria that are more ambitious but shown to be feasible in other contexts) are founded on specific assumptions on technological, policy and other measures or levers, or may be adjusted, subject to community or client choices (Stellschrauben) - in addition to a range of statistical trend projections on economic, climatic and socio-political dimensions.

Economic downturns at the local, regional and international scales; effects of accelerating climate change on the economy, markets and infrastructure; and the ability or inability of local and national governance structure to translate scenarios into concrete goals and actions, will all have significant impact on the ability of a city or region to actually pursue energy autonomy. It is the governmental and planning influence - the ability to seize the power of the levers or *Stellschrauben*, which this dissertation aims to address: the very factors enabling the turning of technical potentials into reality.

1.2 Terms and concepts

Gro Harlem Brundtland, former chairperson of the World Commission on Environment and Development (WCED) famously defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland & WCED, 1987). However the definition has been widely criticised for engaging in a level of abstraction, which renders the WCED definition open to interpretation (Pezzoli, 1997; Mebratu, 1998; Counsell & Haughton, 2006). Governments, communities and individuals have therefore readily adopted this definition, on the one hand, because it is not specifically binding in any way, and on the other, because it facilitates local and adapted interpretations of sustainable development (United Nations Economic Commission for Europe [UNECE], Organisation for Economic Co-operation and Development (OECD), & Eurostat, 2008). The definition’s popularity remains pervasive despite the fact that it offers no specific solution. Its broad acceptance demonstrates that achieving consensus on a generic concept was a better and preferred option than a non-agreement on a focused one (Pearce, Markandya & Barbier, 1989). The WCED definition challenges individuals, institutions and authorities to translate the aspirational goal into particular actions - and even anchor them into permanent measures in order to weather the uncertainties of social, economic and environmental - and last but not least, political change. But without offering specific measures to address all of these factors, ‘sustainable development’ would be unfeasible. By reframing the definition of sustainable development in terms of energy autonomy, by setting energy as a tangible and functional *first* basis for *addressing the triple bottom line,* could real and more practical actions ensue.

1.2.1 Energy autonomy

According to the Oxford Online Dictionary, the word *autonomy* is an early 17th century word derived from the Greek *autonomia*, meaning 'having it's own laws', from *autos* (self) and *nomos* (law) defined as “the right or condition of self-government”, with here the significant meaning of “freedom from external control or influence” (“Autonomy”, 2012). It also refers to two other meanings, namely “a self-governing country or region”, and “(in Kantian moral philosophy) the capacity of an agent to act in accordance with objective morality rather than under the influence of desires”.

Autonomy hence at once connotes and is distinguished from narrower notions of self-sufficiency and autarky, where *self-sufficiency* refers to “needing no outside help in satisfying one’s basic need” (“Self-sufficiency”, 2012), and *autarky*, derived from the Greek word *autarkeia*, and from *autarkes,* meaning being “economically independent of foreign powers, self-supporting, or reliant on no-one”: the Greek word stems are *autos* (self) and *arkein* (suffice) (“Autarkes”, 2012). Three terms are frequently used interchangeably but only the two latter terms are strictly synonymous: their focus is on complete independence from external support. By contrast autonomy is here defined as not necessarily excluding external supply as long as it is controllable within the aims and values of the local area or community at hand.

The *energy* in energy autonomy is throughout this dissertation taken to only mean renewable sources such as solar, wind, water, geothermal and sustainable forms of bio-energy for both power, heat and fuels. It does not include finite climate change-inducing and unsustainable sources of power such as fossil, nuclear, or energy derived from household waste incineration. This is consistent with both the broader term of *autonomy* and of *autarky*, namely in the moral sense, and in the sense of self-sufficiency: only renewable systems are within the timeframe of a stable solar system continuously available and therefore support self-sufficiency enduringly. Broadly speaking, they do not expire or place a deleterious and system-destabilising burden on the natural and societal environment.

Since renewable energy sources by definition are perpetually available, they constitute the appropriate basis of an autonomous energy system. They are emissions- and toxicity-free, adaptable, secure under terrorism threats, and diverse in size and scale depending on the locally available resources. The overwhelming availability of solar energy (Jacobson & Delucchi, 2009) lends themselves to energy autonomy and security in both supply and cost (Scheer, 2007; Cory, Coughlin & Coggeshall, 2008). Renewable energy sources also mitigate the increasing risk and vulnerability of fossil fuel systems. Unlike non-renewable incumbent industries and predecessor technologies, they are capable of operating in a decentralised and interactively networked manner. They provide reserve capacity through redundancy, interchangeability and interconnections between villages, towns and cities. They provide a framework for satisfying local demand and sharing excess renewable energy generated across regions, therefore lessening the reliance on expansive, centralised grids. Intelligent networks and ubiquitous storage systems are part of a functioning, purely renewable energy system.

An autonomous energy strategy is technically composed of five critical aspects. It first aims to reduce energy consumption by all sectors; second, achieve optimal energy efficiencies in both the demand and supply side throughout the entire energy system; third, match supply with demand with by replacing energy imports with endogenous renewable energy sources; fourth, store energy in order to cover intermittencies; and fifth, function independently - either connected to the grid or function as a ‘stand-alone’ or ‘off-grid’ system (Rae & Bradley, 2012; Müller, Stämpfli, Dold & Hammer, 2011; Day, Ogumka, Jones & Dunsdon, 2009).

An early example of the expression appears under 'Regional Energy Autonomy' in 'World Energy Horizon 2000-2020', a volume produced for the 14th World Energy Conference by its Conservation and Studies Committee. It defined the term in a strictly self-sufficiency sense, as the “ratio of demand to supply" (Frisch, 1989, p. 92), and calling for a "vigorous expansion of new energies and nuclear production to counteract the rising tide of oil and gas imports" (p. 94).

'100% Renewable' as a frequent slogan is on face of it a technical call to local or global renewable energy based supply, involves in detail, too, always some form of community strategy of achieving this move. It therefore is occcasionally also referred to here in this sense. As a measurement of its technical aim and performance goal of '100% local renewable supply', energy autonomy here is referred to as a mean annual calculation on the amount of local renewable energy sources that has met the direct energy demand of the municipality. Figure 7 shows the four energy parties used in the technical assessment model referred to in 1.1.3. These make up a typical municipality: households, businesses/trade, industry, and forms of mobility, associating this with the consumption of energy in the form of heat, hot water, electricity and fuels.

Fig. 7. The direct energy consumption of the main urban energy parties (Genske et al., 2013).

Today the term has evolved in a broader and more nuanced sense, and lends itself to association with independent governance, accountability and responsibility, even aspects of morality and ethics in conducting one's affairs. As used here, *energy autonomy* resonates with the usage by Hermann Scheer (2006) who, as we will see below, preferred a more open and encompassing definition of energy autonomy as referring to the overall commitment to a state of autonomy, rather than the numerical and technical accomplishment of self-sufficiency of supply.

In this dissertation, local energy autonomy always implies a clear focus on this self-reliance as a focus, with a '100% renewable' supply as community aim, but as a practical outcome does not always have to refer to the exclusive use of renewable energy that is generated *intra muros*, in other words, renewable energy derived within the boundaries of the local government area (Genske et al., 2009). It can also include renewable energies generated elsewhere, preferably from within the wider region that is exchanged with it, fed into and stored as part of the local and regional renewable energy system. However, this process of regional and wider exchange and therefore the practice of energy import must be under local community control.

Local energy autonomy here refers to the municipal autonomy in managing one's own local energy supply systems, rather than just the ability to meet local energy demands with 100% renewable energy. Indeed, a municipality can be 100% but not necessarily energy autonomous because it does not have that regulatory control. Energy autonomy therefore concerns a special *planning attitude*, not merely a numerical condition as espoused by Herman Scheer:

> "It is not about the mere application of efficiency measures and renewable energy systems to the conventional energy, planning and development regime of a community or nation –

> but about the focused and methodical pursuit of complete local and regional independence from all non-renewable energy sources…[which] *involve strictly local measures, but also engage or rely on regional, state or national support frameworks"* (Scheer, 2007, p. 232).

This dissertation proposes that energy autonomy epitomises an optimal manifestation of sustainable development because it provides a clear goal, a clear framework and a clear performance measure: that is, to optimise energy efficiency in combination with covering all energy demands with 100 per cent RES (Scheer, Ghandi, Aitken, Hamakawa & Palz, 1992; Scheer, 2007). It addresses the three tenets of economic, social and environmental sustainability by placing respective emphases on local economies for the generation of local RES, the participation of whole communities for the support, implementation and ownership of local RES, and the protection of ecology and biodiversity by the sustainable use of local natural resources. In support of the Brundtland definition for balancing social, environmental and economic needs for the present and into the future, CIPRA (2010a) agrees that energy autonomy would "facilitate an equitable way of life and is ultimately the only intelligent way forward on the energy question and climate protection" (p. 27).

Community goals and governance frameworks in planning rather than strict mathematical calculations thus define the limits of this term to this dissertation. The primary focus therefore is to ascertain the appropriate measures and support structures that can guide urban development, vis-à-vis the built environment, towards energy autonomy.

1.2.2 Urban development

Urban development refers to the *process* of settlement change, usually the growth or expansion of building sites and urban areas, transformation of uninhabited areas into built-up areas, infrastructure upgrades, redevelopment of established or the regeneration or renewal of declining or deteriorated urban zones or regions. Urban development touches on town planning, urban planning, spatial planning and urban design, all of which refer to the purposeful design or strategy of guiding that change. It involves the physical design of the built environment, the organization of land use and the design of spaces as a social process. Many of its current concepts are founded on the historical need to respond to the demands of a rapidly growing and industrialising society, where solutions were sought for the creation and organization of settlements that were healthy, moral, civil and equitable; that conserved natural landscapes; and resolved the urban-rural dichotomy (Johansson & Westlund, 2012; Marchand & Cavin, 2007).

Urban development is traditionally shaped by two factors: economic forces and government guidance. The economic factors are largely privately driven and include the market, the designers and the developers. The authoritative or governance factors are regulatory driven and encompass local, regional, state and national governments.

In recent times, sustainability has been named the new "tyranny" of urban development, setting new and unprecedented challenges for actors when shaping urban development (Carmona, 2012, p. 184). According to Carmona (2012), society must now learn how to manage the new technologies and processes that support sustainable development. Traditional practices such as place-making and civic engagement must also pursue the same sustainability goals. The United Nations framework for sustainable development, Agenda 21, asserts that urban development can be a positive tool for the promotion of sustainability. It can influence existing decisions in sustainability but also induce new decisions for positive change (Taylor, 1988), but sustainable urban development as "a form of green-washing, being an end in itself and accepted without question" (Carmona, 2012, p. 186) should be avoided, particularly if energy technologies become the only and central concern.

Urban development can be utilised to address the energy use within the city and the associated GHG emissions through its form and design (Owens, 1986, 1988, 1992; Owens & Powell, 2002). This is pertinent as the rate of urbanisation increases and the demand for more private motorised vehicles, larger dwellings, and more affluent lifestyles rises. These are direct consequences of urban sprawl caused by the growing distances between home, work and leisure. The traditional response in sustainable urban development has been to employ land-use zoning and master-planning, policy priorities such as urban densification and mixed-use development, and the application of urban design quality standards. These have been applied to limit urban expansion, reduce the need and times for travel, increase energy efficiency, and more recently, optimise renewable energy generation within the built environment (United Nations Human Settlements Programme [UNHABITAT], 2011).

As UNHABITAT (2011) suggests, most government programs focus on large-scale regeneration projects and the reuse of abandoned land over smaller more ubiquitous interventions and changes. Usually managed by local governments through planning rules and guiding policies, the effectiveness of projects still depended on the lifestyle, space and energy demands of the city's residents. Large-scale urban development projects often involved cooperation between local and external entities, combining the pursuit of sustainability targets with business interests, as reflected in the growing trend for developing new cities that are 'eco', 'carbon neutral', 'low carbon', 'zero carbon', 'green' or simply 'sustainable'. At the community level, local residents were often led by non-profit organizations to influence local government intervention in urban development projects, such as lobbying for energy efficient technologies as a means to cut down the energy bills of low-income residents. Compared to smaller projects at the neighbourhood-scale, larger urban development projects aimed to accommodate the needs and aspirations of a wider range of stakeholders while maintaining an overall visual, functional and commercial identity based on sustainability.

UNHABITAT (2011) however warns that "the confluence of variety of interests and material circumstances in initiatives to mitigate climate change through urban design and development [can make] them complex and difficult to manage" (p. 95). There will be political resistance, a lack of obligation and limited individual effort. Furthermore, "creating enclaves of sustainable living" may create social inequality and fail to address the basic needs of the rest of the inhabitants. However, these fears fail to recognise that sustainable development does not exclusively mean reaching an absolute energy target but rather, as demanded by the United Nation's Local Agenda 21, establish an exemplary template for sustainable living for new and existing communities. It is a mode of development that can be improved and monitored over time.

Indeed, urban development can be measured in many ways. The rate of growth can be basically determined through calculating population sizes, building densities, transportation use or the consumption of goods and services. Land and property value changes can also be monitored. As for the degree of urban sustainability, this can be ascertained through sustainable development indicators that account for a variety of social, environmental and economic criteria. Several specialist indicators developed for specific urban applications in building and construction have already been developed in Europe such as the German Sustainable Building Certificate (Deutsche Gesellschaft für Nachhaltiges Bauen eV - DGNB), United Kingdom's Building Research Establishment Environmental Assessment Method (BREEAM) and the Swiss Minergie program. At the urban or neighbourhood scale, UK's BREEAM Communities and the Swiss Energy City (Energiestadt) program are excellent examples of frameworks that can directly gauge the progress in local sustainable development and community energy planning. The Energy City program in Switzerland for example, formalised as a brand in 1993, and set up with a catalogue of measures by 1997, targets energy most specifically, recognising those towns and cities, which have reached milestones in energy efficiency and renewable energy implementation (swissinfo, 2005). By 2003, its cooperation with two other international programs: the *energieeffiziente Gemeinden e5* (Vorarlberg, Austria) and *Aktionsprogramm 2000 plus* (Germany), has resulted in the foundation of the larger European Energy Award® association.

This dissertation acknowledges the formal planning concepts that guide urban development as well as the social, economic and environmental influences. It notes that a singular emphasis on technology is neither helpful nor sufficient. Here the measurement of energy autonomy does not focus exclusively on renewable energy technologies but rather the planning environment in which they operate, taking the Principality of Liechtenstein as test case.

1.2.3 Local governance

According to the United Nations Economic and Social Commission for Asia and the Pacific, governance refers to “the process of decision-making and the process by which decisions are implemented... It involves formal and informal actors and can be used in several contexts such as corporate governance, international governance, national governance and local governance” (United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP], 2012, p. 1). Eight characteristics define good governance: “participatory, consensus oriented, accountable, transparent, responsive, effective, equitable and law-abiding” (UNESCAP, 2012, p. 1). In this dissertation, *local* governance is the focus of research since it is the level which climate change mitigation is best addressed (Collier & Löfstedt, 1997; Allman, Fleming & Wallace, 2004; Bulkeley & Betsill, 2005; Hopkins, 2008). Factors such as geography, demography, culture, economy, and legal capacity remain significant influences on municipal practice (Kelly & Pollitt, 2011).

According to the Oxford Online Dictionary, local government is defined as “the administration of a particular county or district, with representatives elected by those who live there” (“Local government, 2012). Granted sufficient authority by the central (usually national) government to govern autonomously, it would directly serve the local constituents through a mixture of mandatory and permissive powers. The former entails legally implementable measures defined by higher levels of government, usually the national but sometimes the regional bodies, the latter leaves the provision of additional services to the discretion of the local authority. Despite relative independence, activities are generally guided by a central government legal planning framework.

Responsible for daily operations, local governments are instrumental in effecting important changes. They can deal with the on-the-ground issues that directly impact spatial, ecological and climatic outcomes. They can manipulate spaces, places, buildings and sites more so than any other regulatory entity through the setting of stringent local standards. They can mediate the needs between individuals or neighbourhoods. They can translate local community aspirations to the central governing body, and conversely translate national strategies back to the community. They are the main mechanism by which citizens can drive local priorities and shape the type and standard of services they require, holding the local authority accountable as service providers. At the same, they provide the platform for empowering local community to take part in decision-making processes and be responsible for the issues that matter most to them (St. Denis & Parker, 2009; Mendonça, Lacey & Hvelplund, 2009; Wiklund & Viklund, 2009; Wolsink, 2010).

In this dissertation, local government is synonymous with municipality and local authority. The word serves to best translate the German word *Gemeinde*, which is a term prevalent in the German literature denoting the elected and administrative structures of the local community, besides also being used to refer to a political entity and geographic place. It sits in contrast to the word *community*, which includes the elected local representatives and the non-elected residents.

Bulkeley and Kern (2006) categorise four modes of governance used by local government to initiate change: self-governing, governing by provision, governing by authority and governing through enabling. Self-governing refers to the capacity to govern themselves, governing by provision refers to the delivery of services, governing by authority refers to the use of regulations and standards, and governing through enabling refers to the facilitation and coordination of partnerships between sectors, including community engagement (See Figure 8). Kelly and Pollitt (2011) uses this framework to categorise local government influence over energy and emissions and found that three out of the four items were intrinsic to the success of local energy strategies in Denmark, Finland, Sweden, Norway and the Netherlands. Critical to the strategies was a local energy plan, strong leadership and working partnerships albeit the lack of a supportive local regulatory framework.

This dissertation does not employ the Bulkeley and Kern framework because the method describes government as a phenomenon rather than as a living driver of change. It is less instructive in relation to operational or functional results since it is very broad and does not refer to specific purposes, aims, policies or outcomes. Figure 8 shows the pros (+), cons (-) and examples for each mode.

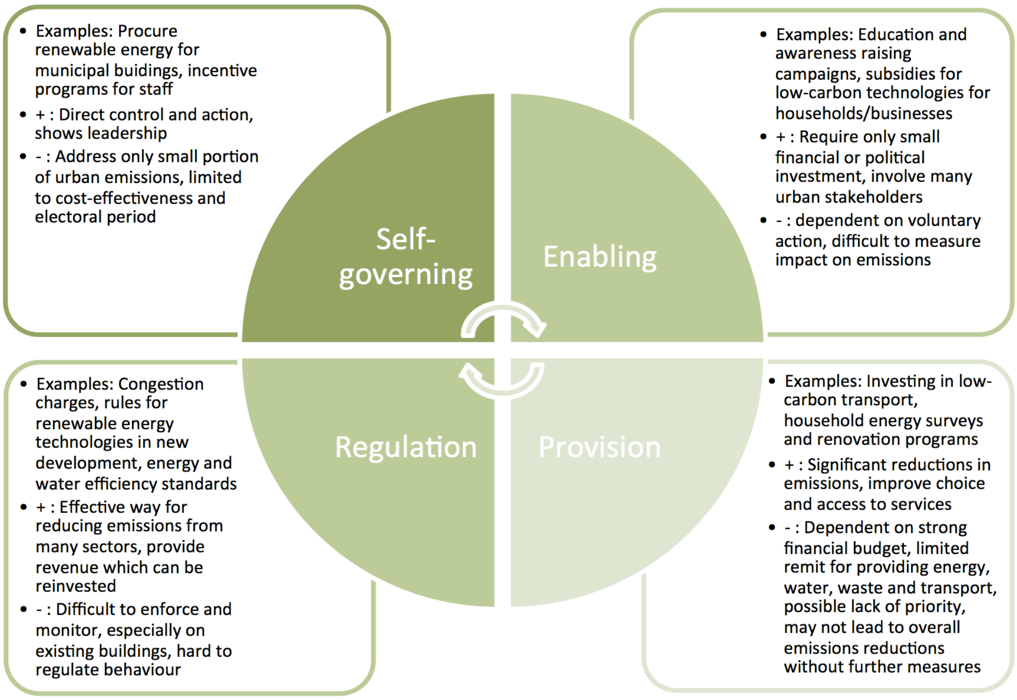

Fig. 8. Four modes of governing for climate change according to Bulkeley and Kern (2006), the pros (+), cons (-). (Adapted from UNHABITAT, 2011, p. 108).

When the United Nation's framework for sustainable development Agenda 21 was extended to include Local Agenda 21 (LA21), the role of local governance became internationally qualified, with formal recognition given to the local authority to "construct, operate and maintain economic, social and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, assist in implementing national and subnational environmental policies…[and become involved in] educating, mobilizing and responding to the public to promote sustainable development" (UNEP, 2013). The community LA21 plan operationalises these elements through community consultation, enabling them to gain consensus on a range of local sustainable development issues such as: shelter, settlement management, sustainable land-use planning, public infrastructure in water, waste, energy and transport, disaster management, and human resources-and-capacity building. LA21 has since been adopted by numerous local governments across Europe.

Indeed, the qualification of LA21 has set off a wave of related European-wide policies in local sustainability. For example, the 'Aalborg Charter' created in 1994 has since encouraged hundreds of European local governments to commit to a set of goals in sustainable development related to the themes of governance, local management, resources, consumption, planning, health, economy, equity and global responsibility (Aalborg+10, 2004). The European policy statement 'Acquis Urban', established in 2003 by European ministers for urban development, has showcased numerous European cities as models of their sustainable development strategy. It is an implementation strategy that links individual projects to form a city-wide vision based on coordinating sectoral partnerships, facilitating investment, supporting capacity-building and guiding project monitoring (EC, 2005).

In Switzerland and Liechtenstein, the Energy City framework run by the public service entity EnergieSchweiz has been adopted by a large number of municipalities in the two countries, which in contrast to the schemes described earlier are based on ongoing local energy audits. As the primary basis of local government energy assessments described in this dissertation, Energy City deploys a quality management system and certification process that helps municipalities to account for, visualise and operationalise local energy and climate protection goals. Implementation through local urban development is kept motivated via an auditing cycle of 4-year intervals, based on a process of accounting, planning, implementing, auditing and adjusting. Local authorities are provided with the necessary advice and instruments to carry out the process, including an energy policy plan template, a measures catalogue, an indicator set, data acquisition methods and evaluation guides. Self-assessment by the local authority is guided across six themes: development or regional planning, communal buildings or facilities, supply or disposal, mobility, internal organization and communication or cooperation (See Figure 9).

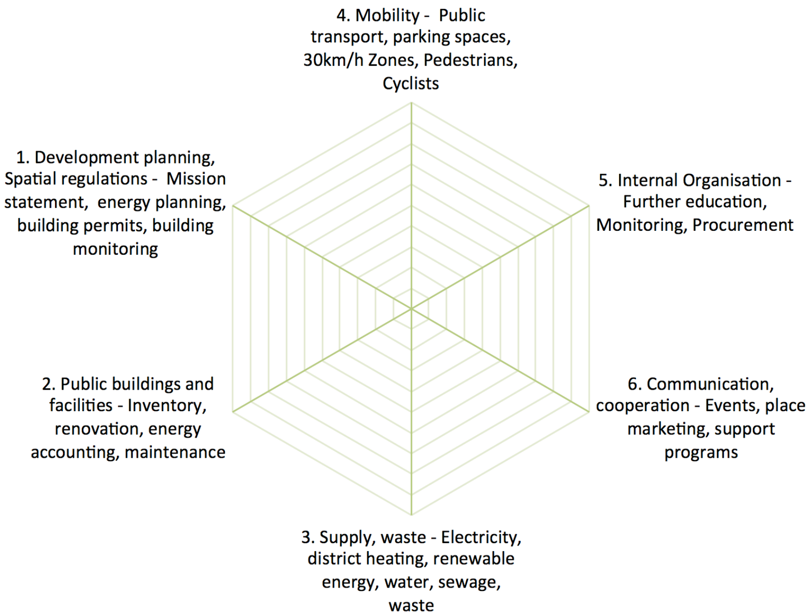

Fig. 9. The six themes of the Energy City framework (Adapted and translated from energiestadt.ch).

It is reminded that the Energy City framework forms the basis of municipal urban development in Liechtenstein, as discussed in Chapter 5. This framework will be tested to determine its capacity to guide the pursuit of energy autonomy by the local governments in the Principality.

1.3 Research questions and early hypotheses

This dissertation seeks ways **to understand how urban development can be governed to achieve local energy autonomy**. It inquires into the need for new policies and actions, examines the sufficiency of strengthening or adapting existing policies with particular regard to building and urban planning, and ascertains any organisational adjustments required to achieve this goal. It sets out to develop an understanding of the actors and stakeholders involved, their roles, their perceptions, and the socio-political context in which they operate.

This dissertation outlines five research questions to collectively address the principal goal. The questions parallel the process which energy autonomy can be pursued, and applies the findings from the global scale through literature, case and expert reviews, to the local scale through capacity analysis of the Principality of Liechtenstein and the municipality of Balzers.

The research questions are as follows:

Research Question 1 As background to this study, what is the state of research into governing urban development with regard to local energy autonomy?

Hypothesis:

Research into energy autonomy remains scarce and limited to technical assessments of energy potentials and cost-optimisation. Urban development and planning aspects are relegated as subsidiary measures in the pursuit of energy autonomy.

Research Question 2 In relation to implementation, what issues should be most critically considered with respect to governing urban development for local energy autonomy?

Hypothesis:

The most critical issues relate to the level of knowledge by the local government administration on energy matters, the advancing of municipal expertise in energy, and the partnering with local industry and scientific community for technical know-how and long-term monitoring.

Research Question 3 In addressing the role of local government, what are the most significant urban development methods employed by authorities who have already achieved energy autonomy?

Hypothesis:

The most significant methods commonly developed are the taking stock of energetic potentials of the municipality, the development of a holistic local energy autonomy concept combined with a integrated action strategy, the revision of building and planning practices geared towards energy autonomy, and the creation of a framework that allows community participation in projects. Despite differences in geographical, economic, social and cultural contexts, approaches to achieve local energy autonomy can and do exist. These approaches however will require significant structural changes to local government and practice, since current governance was formally developed during the modern fossil-fuel based industrial era.

Research Question 4 With particular focus on urban planning, how can local governments effect the transformation of existing policies and frameworks in order to pursue energy autonomy?

Hypothesis:

In the Principality of Liechtenstein, local governments can effect transformation by using their constitutional right to municipal autonomy. They can revise existing building and urban planning codes to include more guidance on energy efficiency and renewable energy integration. They can create integrated local energy autonomy concept that replaces the Energy City concept, which is insufficient to pursue energy autonomy and has moreover encouraged adhoc implementation. Again, these measures would require significant changes to the governance structures of both the national and local governments.

Research Question 5 How can the recommendations for energy autonomy in Liechtenstein be implemented within the context of actual local government capabilities?

Hypotheses:

The recommendations can only be implemented if leadership and political willingness exists within the municipal administration. To counter limited budgets and staff to pursue energy autonomy, establishing partnerships with local organizations can help drive further implementation. To counter the lack of visionary leadership to pursue alternate goals to the 2000-Watt target, further awareness raising amongst and training of municipal administrators and decision-makers can consistently be carried out.

1.4 Research approach

In order to explore the role of governance in guiding urban development towards local energy autonomy, this dissertation employs a **mixed-method approach** that includes literature reviews, surveys, case comparisons, workshops, and individual interviews. The primary focus: the development of an ideal local governance framework for energy autonomy, its use to analyse the capacity of the Principality of Liechtenstein to pursue the goal, and to determine the implementation of practical actions by the municipality of Balzers. The dissertation integrates mainly qualitative investigations, combined with some quantitative research in the form of collecting and comparing data on energy, economy and demographics as supporting material. The qualitative research enables the exploration of ideas and concepts against actual practice, and in so doing, contribute to the testing and improvement of these ideas. Smith, Stirling and Berkhout (2005) argue that this form of research enables the researcher to “create spaces for dialogue across difference, to analyze and makes sense of complex and shifting experiences, identities, and realities, and to understand little and big changes that affect lives” (p. 103). It also facilitates “the conveying of experience of actors and stakeholders as well as the experience of studying the case” (Stake, 2005, p. 454).

1.4.1 Literature review

The dissertation begins with a literature review in Chapter 2, which looks specifically at peer-reviewed literature on energy autonomy, energy autarky, or 100% renewable energy self-sufficiency, screened to only include analyses that deal with municipal governance and development planning. It adopts a thematic approach, organised according to the issues raised and determines the trends and ‘gaps’ in the research on local governance and energy autonomy.

According to Rocco and Plakhotnik (2009) a literature review: “establishes a foundation by using previous work to: demonstrate linkages, trends in concepts, differences in terms and methods; clarify assumptions and limitations; define gaps in knowledge; and generate new frameworks and perspectives on the topic” (p. 122-123). In so doing, the researcher is able to build a rationale for a new study. With regard to the selection of relevant literature, the review should outline what is and what is not within the scope of the investigation, with some justification, and should consider literature that discusses the topic in both negative and positive terms (Torraco, 2005). It should aim to locate new parameters pertinent to the topic, enhance the project vocabulary, link ideas and theories to applications, identify how earlier methodological choices affected the research results, and distinguish between already completed work to work that still needs to be carried out (Hart, 1999).

1.4.2 Delphi method

The surveys in Chapter 3 employ the Delphi method, which is a “structured process for collecting and distilling knowledge from a group of geographically dispersed experts by means of a series of questionnaires interspersed with controlled opinion feedback” (Adler & Ziglio, 1996, p. 3). The aim of this chapter is to determine which aspects should be prioritised when pursuing energy autonomy based on the opinion of experts in the fields of energy, government, urban planning and architecture.

The Delphi method is characterised by anonymity, iteration, controlled feedback and statistical group response (Rowe, Wright & Bolger, 1991). Anonymity is maintained by using written or online questionnaires that are completed by selected experts in their own homes or offices. Iteration begins with the first round survey, which describes the issue, problem, or topic of the study. Participants are asked to list, rank and comment about a range of items. The researcher synthesises the responses and returns the results to the participants, alongside a second round survey. This survey asks respondents to revise their original responses and answer further questions based on group feedback from the first survey. The researcher usually reiterates this process until the respondents reach a satisfactory degree of consensus. Most Delphi inquiries involve 2-3 iterations. This dissertation employs two. Controlled feedback occurs between iterations when the researcher uses qualitative data (expert comments) as feedback to allow participants to comment and critique. The final feedback consists of the statistical group responses showing quantitative and qualitative data.

The key advantage of the Delphi method is that it avoids direct confrontation between experts, since confrontation often lends to "hasty formulation of preconceived notions, an inclination to close one's mind to novel ideas, a tendency to defend a stand once taken, alternatively and sometimes alternately, a predisposition to be swayed by persuasively stated opinions of others" (Dalkey & Helmer, 1963, p. 458-467). It can also engender the feeling of being judged by others in the group (Rowe et al., 1991). Delphi techniques can be used to develop group consensus about the relative importance of issues or to develop a concept or framework. According to Rowe et al. (1991), often group dynamics in Delphi processes, rather than statistical strength, are emphasised to arrive at a consensus. Instead of focusing on bringing expert opinions close to one another, researchers can also determine the level of *dissensus*. According to Landeta and Barrutia (2011), this opens up greater possibilities for interaction and debate, because all constructive contributions are acknowledged in an environment that is more inclusive, with minimal conflicts.

In this dissertation, both the level of consensus and dissensus are explored. Anonymity is maintained. Only experts who participate in the first round are invited to participate in the second. This maintains that second round results are not diluted by opinions of those who do not experience the first round of questioning. Iteration takes place twice in the form of two survey rounds. Controlled feedback is ensured through a brief statistical and descriptive report outlining the results of the first round when the second survey is administered. Instead of leaning heavily on the statistical outcome of the surveys, the Delphi in this dissertation is used predominantly to "brainstorm, narrow and rank ideas" (Häder & Häder, 2000) in order to generate and refine a conceptual framework for energy autonomy. This refers to the policy framework originally developed for the World Future Council as part of their 'Urban renewable power policy toolbox' (Droege et al., 2010).

1.4.3 Comparative method

A comparative approach is employed in Chapter 4 to analyse the three energy autonomous communities of Wildpoldsried in Germany; Güssing in Austria; and Samsø in Denmark. It aims to first compare how actual practice compares with expert opinion and second, to help further refine the framework for energy autonomy developed in Chapter 3. The framework provides the variables that would structure the comparison of cases.

The comparative method is "a method of discovering empirical relationships among variables, not as a method of measurement" (Lijphart, 1971, p. 683). It is a method that can be applied to a small number of cases (three in this dissertation) because analysis can be extended geographically and historically. In this dissertation, the comparative analysis is conducted on comparable cases, which means "similar in a large number of important characteristics (variables) which one wants to treat as constants, but dissimilar as far as those variables are concerned which one wants to relate to each other" (Lijphart, 1971, p. 685-696). By using comparable cases, the relationships among a few variables are established while many other variables are controlled. The number of key variables is restricted to energy autonomy factors originally advanced by Droege et al. (2010), and as refined through the expert voices brought to bear in Chapter 3. The cases are analysed against these factors.

The cases are chosen on the basis of their contextual similarity with the Principality of Liechtenstein and their instructional potential. The cases would enable the researcher to observe operations (Kemmis, 1980), in order to "provide insight into an issue or to redraw a generalisation" (Stake, 2005, p. 437), all with respect to "the elements, relations among elements, the development of the object, and contextual influences" (Zeisel, 2006, p. 98). This dissertation adopts the view that the systematic and contextualised comparisons of cases “does not directly aim for universally applicable knowledge, but it makes dialogue between theory and evidence” (Mahoney & Rueschemeyer, 2003, p. 13).

1.4.4 Diagnostic research

Chapters 5 and 6 of the dissertation employ *diagnostic* research in order to understand the energy and governance situation in Liechtenstein. This seeks to determine whether in light of the social, economic and environmental issues involved, energy autonomy could be ultimately be pursued by local and national governments in Liechtenstein. The diagnostic research would provide “insight into the structure and dynamics of a whole situation” (Zelsel, 2006, p. 93).

Document review, workshops and individual discussions with local decision-makers including national and local government representatives of Liechtenstein form the central basis of this inquiry. Work conducted through the Lake Constance Alpine-Rhine Energy Region (BAER) research project is cited as integrated, along with input from team members who assisted in framing the issues and helped structure the overall collaborative process.

The principal case study of Liechtenstein sits within the context of the BAER research project, which aims for a catalogue of recommendations for an energy autonomous region. In this way, Liechtenstein, as one of the member States of the Lake Constance regions, is presented as containing potentially exemplary models and messages for this region.

Through the diagnostic research, any organisational changes required to transition from fossil-fuel based urban development to one that is based on renewable energy are ascertained. An analysis of the development of energy and its impact on local and national spatial planning (and vice-versa) are carried out, structured according to the six factors for energy autonomy developed in the previous chapters. These are compared with expert opinions and the energy autonomous case communities. The history, economy, environment and social influences are understood through the analysis of historical documents, legislation, codes, national and municipal reports and minutes. Further information is provided by individual interviews with four national officials and two energy consultants to the municipalities. To evaluate the willingness of decisions-makers to support energy autonomy as a vision for Liechtenstein, two workshops are organised, comprising 17 officials from the national government, the municipalities and the national energy providers.

An additional third, and final, workshop – which forms Chapter 6 – evaluates the technical and governance as well as the communal potential for the municipality of Balzers in Liechtenstein to become energy autonomous, exploring more closely the role of local government in the transition.

This last workshop provides the basis for local government to learn about energy autonomy and act in a collaborative but independent manner to pursue this goal. It sets into motion a type of action research - or reflective implementation process - that municipalities can undertake by themselves, but in combination with external feedback, to solve the issues that have traditionally prevented them from achieving energy independence. By undertaking their own form of collaborative learning, municipalities can solve problems in a democratic and collective way (Greenwood & Levin, 2005). The process aims to reveal unspoken customs and shared assumptions, taking what Kamberelis describes as “the interpretive process beyond the bounds of individual memory and expression to mine the historically sedimented collective memories and desires [recognising that] “real-world” problems cannot be solved by individuals alone: instead, they require rich and complex funds of communal knowledge and practice” (Kamberelis & Dimitriadis, 2005, p. 903).

The process benefits both from long-term local knowledge, and from professional knowledge in precedence and methods brought in by the researcher - or in this case, the external energy consultant - giving the overall process a sense of urgency (Atkinson & Delamont, 2005). It also incorporates a collaborative communication process in which a) all comments are considered, b) diverse experience and capacities within the local group are embraced (to enrich the process), c) valid findings are produced, and d) real, practical problems are solved (Greenwood & Levin, 2003). Rather than as the 'expert-in-charge-of-change', the researcher (or energy consultant) is a 'co-learner' who can 'fade out' as municipal participants take charge of their own learning and actions.

1.5 Research outline

This dissertation integrates theory, expert feedback, case study and application. Chapter 1 explains the context, the terms and the dissertation structure. Chapters 2 to 4 presents the development of a theoretical framework for governing energy autonomy based on academic literature, expert opinion and case communities. Chapters 5 to 6 examine the potential of an actual country and its local communities to achieve energy autonomy, by which their capacities are tested against the energy autonomy criteria developed earlier. In relation to the five research questions, these are addressed in each corresponding Chapter from 2 to 6. The dissertation ends with Chapter 7, which synthesises the major findings, provides recommendations for governing for local energy autonomy in general, and then with specific regard to the Principality of Liechtenstein and the municipality of Balzers, culminating in a discussion on the research limitations and future research.

Chapter 1 provides an introduction to energy autonomy, its definition, and its role relative to sustainable development. It introduces the three research projects which the dissertation is based, and clarifies its context in relation to resilience, urban development and local governance. It explains the questions and hypotheses the dissertation seeks to address and outlines the research approach.

Chapter 2 examines peer-reviewed literature on urban development methods that directly targets energy autonomy by local government. Literature would also encompass the key areas of 100% renewable energy self-sufficiency and energy autarky. The research 'gaps' in terms of focus and method are identified in relation to this field of local energy autonomy governance.

Chapter 3 presents the results of the 1st and 2nd Delphi surveys into governing urban development for local energy autonomy. Feedback from experts in the field of architecture, urban planning, energy and governance are analysed and contrasted. Responses are used to refine the energy autonomy framework: 'Urban renewable power policy toolbox' developed by Droege et al. (2010).

Chapter 4 focuses on the urban development methods implemented by the municipalities of Güssing in Austria, Wildpoldsried in Germany and Samsø in Denmark, who have all achieved 100% in heating or electricity. These measures are analysed according to the refined energy autonomy framework developed in Chapter 3, and are contrasted with expert comments from the Delphi Survey. The results culminate in the rearrangement of framework criteria according to actual practice.

Chapter 5 investigates the Principality of Liechtenstein as a model for achieving energy autonomy. It determines the capacity for the country to achieve this goal by examining incumbent policies, strategies, projects and organisational frameworks in energy at the local and national government levels. It examines building and planning regulations and its effects on energy planning. It also presents the results of the workshops and survey, which involved 17 decision-makers within Liechtenstein. The Renewable Liechtenstein research findings and the national Energy Strategy 2020 form the basis of the discussions. It compares the national with local perceptions, understands the fears and misconceptions and draws out recommendations for achieving the goal of energy autonomy. Through such evaluations, an appreciation of the achievements and determination of areas for potential improvements is gained. It also informs an understanding into the role of local and national government in Liechtenstein to achieve energy autonomy.

Chapter 6 focuses on the findings of a community local energy autonomy workshop involving local decision-makers, energy experts and community groups in determining the capacity of a local government to actually pursue energy autonomy based on the improvement of existing practices and further development of incumbent energy frameworks, and the development of measures defined by the energy autonomy framework developed in the previous chapters. In this case, the municipality of Balzers is the focus and the Energy City framework is the incumbent measure.

Chapter 7 synthesises the findings of Chapters 2 to 6, and provides the key ingredients and recommendations towards governing urban development for local energy autonomy in two parts: first, as universal recommendations for local governance, and second, as specific recommendations for the Principality of Liechtenstein and its local governments, in particular with their involvement in the Energy City process. The chapter ends with a clarification of limitations in the dissertation research and an explanation of the importance of the overall research in the context of prompting future work on governance in pursuit of local energy autonomy.

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The following Figure 10 illustrates the dissertation research outline:

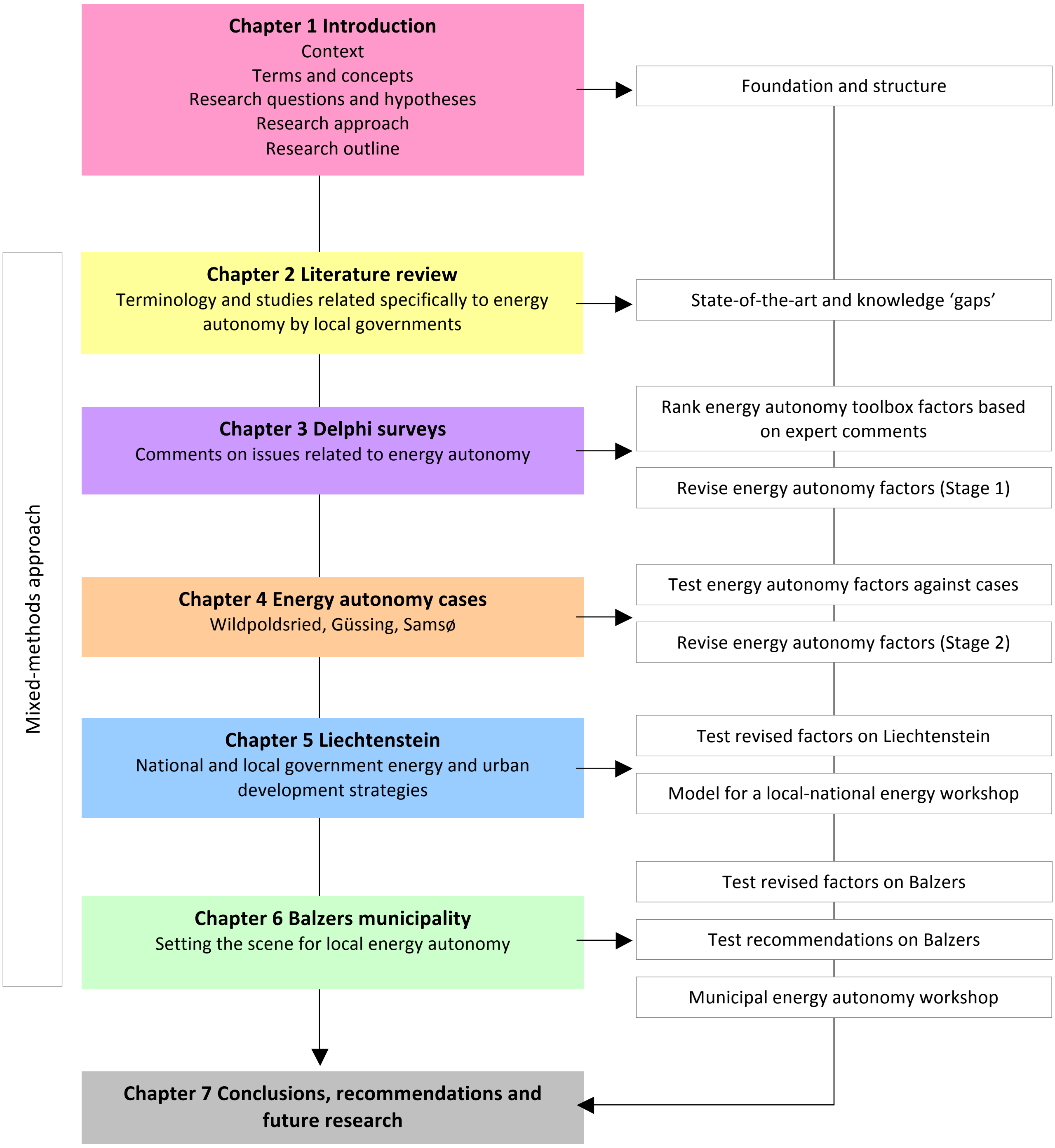


Fig. 10. Dissertation research structure.

Chapter 2. Literature review

2.1 Context

A large body of research already exists that touches on the efforts of local governments in driving energy efficiency and RES integration as part of a greater sustainability agenda. These largely addressed aspects of community and self-governance. Societal issues related to socio-political acceptance (Devine-Wright, 2005a, 2005b; Michalena & Angeon, 2009; Wolsink, 2010), community energy ownership (Walker & Devine-Wright, 2008; Clark II & Eisenberg, 2008; Rogers et al., 2008; St. Denis & Parker, 2009), and local capacity building (Wolsink, 2000; Agterbosch, Meertens & Vermeulen, 2009). Self-governance dealt with diagnosis and scenario building (Terrados, Almonacid, & Hontoria, 2007; Bhatt, Friley & Lee, 2010; Neves & Leal, 2010), national energy policy into local policy translations (Collier & Löfstedt, 1997; Izutsu, Takano, Furuya & Iida, 2012), municipal energy plans and policies development (Hull, 1995; Nilsson & Màrtensson, 2003; Polatidis & Haralambopoulos, 2004; Ivner & Gustafsson, 2011), planning process appraisals (Day et al., 2009; Khan, 2003; Nadaï & Labussière, 2009; Gibson & Howsam, 2010), and environmental and socio-economic assessments of local energy projects (Burton & Hubacek, 2007; del Rio & Burguillo, 2009). None of these studies however addressed the topic of energy autonomy.

For an increasing number of municipalities, energy autonomy has now become a real policy goal, implemented through concrete urban development measures that optimise energy efficiency and renewable energy integration. As renewable energy technologies become increasingly ubiquitous, their proliferation presents an interesting challenge for decision-makers, builders, developers and owners.

2.2 Approach

To investigate the state-of-the-art in local governance and local urban development research with regards to energy autonomy, peer-reviewed literature on local governance were selected according to the key words of energy autonomy, energy autarky, energy self-sufficiency and 100% renewable energy, where energy would refer to only renewable sources. The resultant literature was then filtered to only include those that specifically address urban planning methods, policies and regulations, items most pertinent for *local* decision-makers to pursue energy autonomy. The literature review was then structured according to the types of renewable energy sources commonly discussed, the issues and challenges in implementation, the role of local and national governments, the research methods employed, and the research limitations. The literature review did not examine local governance in isolation but also took note of any community, regional or national influences that may have impacted efforts on local energy autonomy.

The review then addresses the following research question, as formulated in Chapter 1:

‘Research Question 1 As background to this study, what is the state of research into governing urban development with regards to local energy autonomy?’

2.3 Literature overview

Twenty-five peer-reviewed articles were found to fit the abovementioned criteria. The focus of the research was found to focus on five areas: terminology, economy, society, government and spatial development.

First, the level of acceptance of energy autonomy depended on how well the term was understood and defined, whereby authors attempted to express their own understanding based on what suited their own particular context and needs. Second, renewable energy technologies were shown to be cost-effective as numerical modelling demonstrated that renewable energy generation was as competitive as conventional energy. Third, the rise of community renewable energy reflected the growing impact of community, municipality or cooperative energy ownership in accelerating local energy self-sufficiency. Forth, governmental intervention had shifted towards the need to coordinate relevant actors, devolve power to local government, create feedback mechanisms and policy coordination between local and central governments, and implement financial and market incentives. Fifth, the differences in urban development approach depended on the scale of energy autonomy chosen (and achievable) at the local, regional or national levels, whereby their level of success depended on the size and number of organizations supporting them. Categorised in relation to buildings, regions and islands, urban development in energy autonomy can range from zero-energy or net zero-energy buildings to energy regions, renewable islands and 100% renewable countries.

The research was mostly European-based, residing in journals on energy policy and renewable energy and mainly focused on rural and regional areas. Empirical research outnumbered qualitative research, especially with regards to the usefulness of computer models to manage energy supply and demand, assess economic, social and environmental impacts, and develop scenarios to test alternate policies, necessary considerations for decision-makers when developing policies for energy autonomy. The qualitative methods employed generally involved reviewing literature on technologies, conducting interviews and questionnaires with energy stakeholders, and undertaking historical analyses of energy policies. In terms of the renewable energy source, decentralised energy based on biomass, small-scale generation systems based on solar thermal and solar photovoltaics, and energy storage systems based on hydropower, were in that order, most commonly referred to and were mainly discussed in terms of their energy potential, spatial impacts and economic benefits.

The following section presents a more detailed analysis of the literature content, divided according to energy types, renewable applications, governmental role and research methods.

2.4 Renewable energy types

Bio-energy represented the most commonly discussed RES, mainly in the context of rural areas, characterised by high agricultural and forestry outputs and low-levels of industrialisation. Studies generally focused on the impacts of *increasing* or *decreasing* biomass production. For instance, the necessity to scale-up biomass production to achieve self-sufficiency targets was shown to have some negative impacts on energy and environmental costs (Zhang & Fu, 2011; Schmidt et al., 2012), even in the face of positive growth of bioenergy villages and energy regions such as those in Germany (Kunze & Busch, 2011; Müller et al., 2011). It also competed with food production and other RES technologies such as photovoltaics, solar thermal and heat pumps (Schmidt et al., 2012). Others demonstrated that the dependence on biomass can actually be decreased through the expansion of district heating networks based on other RES such as solar thermal, geothermal and waste energy (Mathiesen et al., 2012) or replacing biofuels with synthetic fuels in transport (Mathiesen et al., 2011). Overall, the articles reflected the growing need to manage the accelerating demands required for energy autonomous systems in the face of land-use competition and dwindling organic resources. It extended existing debates on how to determine the appropriate balance when using natural resources for fuel, food, habitat and carbon sequestration (Burgess et al., 2012).

Photovoltaic systems were the second most commonly referred to RES. Research primarily focused on promoting energy self-sufficiency at the *household* level. This would be achieved through for example the remuneration of photovoltaic electricity generated by small-scale, distributed generation and storage systems by households in urban settings (Colmenar-Santos, Campíñez-Romero, Pérez-Molina & Castro-Gi, 2012), the recommendation of financial incentives and market support for rural households (Zhang & Fu, 2011), the simplification of the technology to ease installation and maintenance of photovoltaic systems in rural communities (Andrade, Rosa & da Silva, 2011), or the certification of photovoltaic electricity in net-zero energy buildings (Sartori, Napolitano & Voss, 2012; Dall'O, Bruni & Sarto, 2013). Generally, the emphasis was on the distributed, the small-scale, and the household as generator and user of RES.

Following bio-energy and solar photovoltaics was the focus on hydropower and windpower. Community acceptance, supply management, socio-economic effects and roles in the whole systems approach to energy generation and storage were the most common issues discussed in relation to this energy source. In the Lake District, England, the acceptance of hydropower was addressed through the implementation of community renewable energy (Allen, Sheate & Diaz-Chavez, 2012). In the Amazon, small-scale hydropower was shown to suit local conditions and be easily managed by the local communities themselves (Andrade et al., 2011). In order to achieve the vision for 100% renewable electricity, hydropower storage was shown to ease the integration of fluctuating RES into the energy system (Giatrakos, Tsoutsos & Zografikis, 2009; Glasnovic & Margeta, 2011; Krajačić et al., 2011a, 2011b). Meanwhile, in the regions of La Rioja and Navarra in Spain, the impact of wind power implementation required the analysis of both the cost-benefits and landscape impacts (Gonzalez, Lizarraga, Tabarés & Ochoa, 2007a, 2007b).

Although the renewable energy sources such as deep geothermal, heat pumps, waste heat recovery and wave energy were not specifically mentioned, these still formed part of the constellation of energy sources in articles that discussed energy autonomy as part of an overall system, in particular studies that analysed the impact of 100% renewable energy systems that considers all, or a combination of, renewable energy sources. Indeed, simulations of a 100% scenario were already carried out for the countries of Denmark (Lund & Mathiesen, 2009; Mathiesen et al., 2011, 2012), Macedonia (Ćosić et al., 2012), Ireland (Connolly et al., 2011), Croatia (Krajačić et al., 2011), Portugal (Krajačić et al., 2011) and New Zealand (Mason, Page & Williamson 2010). In addition, 100% modelling were also conducted for the islands of Réunion (Praene, David, Sinama, Morau & Marc, 2012), El Hierro (Iglesias & Carballo, 2011), Kinmen (Liu & Wu, 2010) and Karpathos (Giatrakos et al., 2009). Overall, the studies focused on technical and economic assessments of a 100% renewable energy scenario, positioned as an alternative vision to the incumbent energy system. Governmental policies were viewed as important instruments to support this scenario.

2.5 Renewable energy applications and issues

2.5.1 Terminology

There were some conceptual difficulties into finding the best term to describe local energy self-sufficiency, with energy autarky pitted against energy autonomy. Depending on its definition, the words caused some ideological conflicts for a few researchers. There was a reluctance to adopt the word *autonomy* by Schmidt et al. (2012), Müller et al. (2011) and Späth and Rohracher (2010), as the word was viewed to be more commonly associated with *political autonomy*, whereby governments would possess political independence, to act as they wished, and in the context of energy, therefore exercise their freedom to either produce or import RES as they find necessary. The researchers preferred the word *autarky*, as this they argued, better matched the idea of local self-sufficiency, that is, to rely only on internal resources, with no RES imports.

However, as one of the proponents of energy *autarky*, Schmidt et al. (2012, p. 5802) admitted that it was unrealistic for communities to exist in isolation since regions were "open systems that exchange information, persons, materials and also energy with one another, with mutual benefit." Exclusivity from other localities and regions could mean the loss of benefits from trade and other economic exchanges, inequity in benefits between different local community actors and the inability to balance fed-in surpluses in renewable electricity, such as balancing energy production in summer with winter imports. Rae and Bradley (2012) argues that an absolute energy scenario would also mean higher costs alongside virtually no income because energy exports in an energy autark scenario would not be possible. Also, extra public works would be needed to maintain exclusive local supplies.

The importation of renewable energy electricity through the regional grid should therefore be permissible within an energy autonomous system. As a consequence of this, Schmidt et al. (2012) has recommended the phrase *relative energy autarky* because this makes energy balancing possible between sectors, seasons and beyond boundaries. Interestingly, the technological possibility and the economic benefits from balancing supply and demand through storage systems and exchanging electricity production surpluses has even been demonstrated in several modelling studies of 100% renewable energy systems (Krajačić et al., 2011; Mathiesen et al., 2011).

Despite the semantic differences, the phrase *energy autonomy* has gained credibility and popularity through the writings of former German politician Herman Scheer (Scheer, 2005, 2007, 2011) and others (Droege, 2006, 2008, 2009). As described in Chapter 1, their adoption of the term is unapologetic and aims for a holistic approach for achieving energy self-sufficiency based on renewable energy from first and foremost, local resources and second, from regional or national resources. This is achieved through a local energy infrastructure that is embedded within a regional network, giving the community or locality the possibility of either working independently *or* being part of a renewable energy grid. For them, the term extends to a self-sufficiency that also enables social and economic self-innovation in transforming the energy system.

No matter the term, Späth and Rohracher (2010) acknowledged that as ideographs (van Lente, 1993), concepts such as energy autonomy or energy autarky were significant for capturing the imagination and attention of communities. They connoted positivity, "offering possibilities for progress, whereby the promise gives a certain freedom to explore and a societal obligation to deliver" (Borup, Brown, Konrad & van Lente, 2006, p. 291). In the analysis of the energy region of Murau in Austria, Späth and Rohracher (2010) found that the energy region vision, taking the *Leitbild* approach (German for model), was necessary to appeal to the local preference for regional economic benefits based on local energy infrastructure and ecological protection, particularly relevant to the region's farmers. The vision evolved into a moral obligation for communities as the benefits became clearer and tailored to specific actors. This enabled the unification of expert and non-expert opinion, the tempering of criticisms and the building of stakeholder coalitions.

Furthermore, the success of local activities in Murau was noted to have shifted discussion at the regime level (Späth & Rohracher, 2010) in that the awareness and sensitisation to the achievements impacted the level of discourse and caused some changes to national government policy in Austria. Similarly, Smith et al. (2005) pointed out that in England, visions also shifted political paradigms albeit *only in terms of language*. The literature showed that overall, energy autonomy as a vision best served to illustrate possibilities, stimulate interest, establish networks, focus resources, inspire development and provide a stable commonality. The main difference in approach depended on whether energy autonomy was conceptualised in technical (Mathiesen et al., 2012) or programmatic (Müller et al., 2011; Späth & Rohracher, 2010) terms.

2.5.2 Economy

There were many analyses demonstrating the economic benefits of renewable energy technologies, particularly in rural and regional areas. These specifically focused on network power stability, income generation, economic activity and regional innovation respectively (Colmenar-Santos et al., 2012; Zhang & Fu, 2011; Mathiesen et al., 2011; Schmidt et al; 2012; Späth & Rohracher, 2010). One particular strength was the ability of fed-in surplus electricity to offset network power losses and to lower grid energy price. Colmenar-Santos et al. (2012) stated, “for approximately every kWh produced by the photovoltaics system to support a household, the whole system would reduce its power losses by a similar percentage” (p. 763). Other benefits included the role of energy storage in 100% renewable energy systems to prevent the shedding of surplus renewable energy generation and make possible the competitive trading of renewable electricity on the international market (Krajačić et al., 2011; Mathiesen et al., 2011).

Some researchers however highlighted some shortcomings when dealing with existing energy consumption patterns and the need to scale-up renewable energy production to achieve energy autonomy. Despite advances in fuel technology, Krajačić et al. (2011) found that total independency could not be achieved in Croatia because different sectors had different fuel needs, which makes energy savings in current systems even more critical than mere fuel substitutions. Schmidt et al. (2012) conceded that although it was possible to replace fossil fuel use for heating by increasing biomass production at a low cost, energy costs will still rise, and food production for local communities and farms will still decrease because it will require more land to optimise biomass production from agriculture and forestry as well as to maximise the use of renewable energy technologies such as photovoltaics in solar farms. Kunze and Busch (2011) also emphasised the inevitable land-use competition, arguing that energy production would not be sustainable if it caused any reduction in food production. With such space limitations, the implementation of a wide range of renewable energy technologies (Müller et al., 2011) therefore becomes essential.

2.5.3 Society

The social dimension in energy autonomy was another common theme in the literature, and was shown to often overshadow technical or even economic concerns (Weidner & Metz, 2008; Späth & Rohracher, 2010; Kunze & Busch, 2011; Hauber & Ruppert-Winkel, 2012). In seven rural renewable energy projects in the state of Brandenburg, Germany, it was found that development process were often slowed down by political disagreements and placing renewable energy production as a low priority. There was a tendency to relegate renewable energy sources as a “hurdle or luxury in order for it to be dropped and the rest of the project to be saved” (Kunze & Busch, 2011, p. 6). In other studies, implementation has been highly dependent on continual active support from local political structures and the need to demonstrate good economic feasibility (Weidner & Metz, 2008; Späth & Rohracher, 2010). The size and level of success of renewable energy projects depended heavily on the size/scale (and the attitudes) of the entities supporting them (Rae & Bradley, 2012).

Furthermore, strategic argumentation and the careful management of actor interests were key. In the Austrian energy region of Murau, credibility, acceptability and trust had to be established amongst the community from the outset in arguing for energy autarky. There, a precise strategy was required to deal with various sectors of society: starting from choosing the right argument adapted to specific groups based on local conditions that highlighted local benefits, excluding related issues that might be controversial for some, avoiding conflict with dominant interests such as national utilities, and not assuming drastic organisational or infrastructural transformations (Späth & Rohracher, 2010). In Murau, the energy region vision based on energy autarky simply required practical demonstrations of regional benefits.

The coordination of energy autonomy with local needs was paramount. In England, the creation of the Cumbrian Community Owned Renewable Trust in the Lake District National Park secured almost instant support from the local community for the various local energy projects. In Brazil, Andrade et al. (2011) found that local energy planning that targeted local benefits in parallel with local ecological conservation helped rural communities in the Amazon to manage their local energy supply, without the need for distant centralised intervention.

The coordination of roles and objectives in energy autonomy *between* levels of government was critical. In a comparison of municipal energy plans with the national government's 100% renewable energy vision in Denmark, Sperling, Hvelplund and Mathiesen (2011) found that local plans were inadequate because measures were mostly anticipated *intentions* rather than soon-to-be implemented actions. They were also largely voluntary, lacked strategic detail, did not coordinate with national measures, or even defined the exact obligation of the municipal government, whether it was to pursue a 100% target, cut emissions or both. Further to this was the challenge for local government to become more "pro-active rather than reactive" (Rae & Bradley, 2012, p. 6504) and to attribute definitive roles and responsibilities to actors within local government that would be responsible for the energy transition.

However, the literature showed that local governments could guide community renewable energy schemes (CRE) as an alternative to relying on centralised support for local energy projects. Centering on local renewable energy production governed or maintained by the communities themselves, it is a bottom-up approach that enables residents to engage in the decision-making of renewable energy projects, develop ownership models, secure local supply chains, influence behaviour, operationalise the local energy vision, and take share in the production and distribution facilities. Prevalent to literature on CRE was the *devolvement of powers* to local governments, cooperatives or even individual residents, to facilitate these activities (Andrade et al., 2011; Kunze & Busch, 2011; Allen et al., 2012). In the case of Denmark, Sperling et al. (2011) asserted that the country must at least assign the necessary responsibilities to the municipalities, and give them the necessary tools to plan and implement local energy projects if they wish to become 100% renewable. Furthermore, project implementation should ideally be *shared* between local, regional and national governments at any given time.

Indeed, CREs were shown to best address the issues of acceptance of RES, the lack of or inadequacies in national government assistance for RES and the wastage in fuel costs associated with imported fossil or nuclear energy. *Increasing* earnings was seldom the primary intention for establishing CREs (Hauber & Ruppert-Winkel, 2012).

2.5.4 Government

Discussions regarding government generally revolved around determining the appropriate role of governments, whether at the national, regional or local, when transitioning to energy autonomy. Governments were categorised as leaders, policy-makers, mediators, authorisers, coordinators or providers (of finance, incentives and information) (Späth & Rohracher, 2010; Sperling et al., 2011; Andrade et al., 2011; Schmidt et al., 2012; Allen et al., 2012).

At the national level, the authorisation of local action in energy efficiency and renewable energy was the focus of research by Andrade et al. (2011) who examined the revision of national energy policies to prioritise decentralised generation based on local and renewable sources, and Allen et al (2012) who highlighted the role of the national Decentralisation and Localism Act 2011 in England which authorises local authorities and communities to match national endeavours in sustainable development through engaging its own local services and resources. As mediator, governments were called to engage the local community, draft local energy strategies, lead local energy projects and be involved in the development of national energy policies. Allen et al. (2012) advised, "that if local authorities are to target their efforts, they also need to know who wants to change and who needs to change" (p. 7). Weidner and Metz (2008) showed that a committed mayor and the involvement of environmental organizations in local energy activities were essential, as was the case in the energy autonomous municipalities in Germany. Hauber and Ruppert-Winkel (2012) emphasised the role of key leaders as 'pioneers' and potential 'entrepreneurs'. By creating an 'inner circle group of mediators' which include government, businesses and the public, Späth and Rohracher (2010) also showed that initiatives were better coordinated and results better communicated.

Sperling et al. (2011) emphasised the need to allow for municipalities "to take part in drafting in national energy policy and legislation and be given flexibility to experiment with new legal or economic incentives" (p. 1346). They suggest that adjustments in national planning processes should enable influence on municipal planning practices, with successes in local measures able to also impact national policies. In their review of energy autonomy in the context of sustainable development, Rae and Bradley (2012) noted that local governments should also move away from the traditional 'propose-object-defend' approach to managing urban development, particularly for local energy projects (Upham & Shackley, 2006). Instead, participatory procedures for energy autonomous urban development should be in place to better respond to place, scale and community (Intergovernmental Panel on Climate Change [IPCC], 2011). In addition, the normalised practice of developing broad planning guidelines should also be replaced with appropriate planning methods that could assist developers to build projects according to the potentials and demands of specific energy technologies (Giatrakos et al., 2009).

The emphasis on the local did not necessarily mean placing lesser significance on other levels of government. Instead, it had more to do with practically shortening distances between energy generation and final user to prevent energy losses and to minimise the amount of infrastructure required for its distribution. It is a technological imperative that has been translated as a governance imperative, 'shortening the distance' between policy-maker and final user. For example, the idea of keeping renewable energy generation *close* to where it is most needed through the construction of local energy plants, manifested in England's own community renewable energy programs (Allen et al., 2012). Another example was the local energy management by communities in the Amazon, which was the result of the failure of Brazil's *national* electrification program for rural areas to take into account the remoteness of communities, the lack of equipment, the high costs related to servicing, and the social needs related to income and employment (Andrade et al., 2011). There, the national government was too geographically and politically removed to grasp immediate local issues.

In terms of its influence, local action was shown to inspire, mobilise and inform action and direction at even higher levels of government. The success of the Austrian energy region vision in Murau for example, has meant its adoption by several regional municipalities and small planning associations comprising several municipalities, districts, a region and a province. This is despite its original purpose for *rejecting unsuitable development* rather than to achieve energy autarky (Späth & Rohracher, 2010). The Murau example affirmed the belief that pioneering local governments did have the capacity to influence regional and national energy policies when it comes to pursuing energy autonomy (Scheer, 2007).

There is no doubt however that local government will still depend on continual high-level government leadership and guidance. Allen et al. (2012) noted that in England, local energy visions were more effective if they were part of a more ambitious regional, national or international initiative rather than just as a basis for a local decentralised energy network. Sperling et al. (2011) found that Danish municipal energy plans were more likely to be translated into real action if national technology-oriented regulations and formal energy planning instruments were also provided, not to mention municipal feedback mechanisms into the national energy framework as an incentive.

Indeed, researchers have noted some shortcomings in national government policies especially in controlling the consequent effects of policy implementation. In Brazil for example, the national electrification program for rural areas in the Amazon, which aimed to provide universal access and reduce poverty by forgoing the power connection fee to the consumer, did not foresee rising costs due to the demand for equipment, service fees and maintenance, not to mention the remoteness of the individual communities from the nearest energy source. Furthermore, the electricity, which did reach communities were only sufficient for general communication, illumination and other basic household needs, but not enough for setting up local businesses (Andrade et al., 2011). Indeed, the general nature of national policy has meant improvements in some aspects but deficiencies in others. In the La Rioja Autonomous Community in Spain, Gonzalez, et al. (2007a) showed that although electrification for remote establishments was successfully promoted, there were no measures guiding sustainable building at the local level.

National regulations were generally referred to more often than local policies, the latter not so much unspecified as to reflect their inability to implement real action due to their non-statutory nature. The former was considered best place to target infrastructure, generation, distribution and education. Researchers proposed several national laws that could impact action at the local level. Andrade et al. (2011) proposed reducing taxes on highly efficient generating equipment and mandate the generation energy from renewable energy sources as part of the energy mix by utilities. Zhang and Fu (2011) recommended exemption taxes in producing and purchasing renewable energy sources, and rebates and market support in form of training, information and technical assistance. Krajačić et al. (2011) emphasised energy supply regulations, for example, for heat and power, electricity trading and surplus electricity production. Mathiesen et al. (2011) focused on awareness campaigns, advanced product standards and best-practice products installation to influence household demand.

In relation to local policies, these largely dealt with in-direct and wholly voluntary actions such as creating local energy visions, organising stakeholder participation, providing information on available subsides and technologies, promoting public transport and public fleets, and green procurement. Direct actions largely dealt with the retrofitting of public buildings, heat and electricity contracting, efficient street lighting, and promoting renewable energy and combined heat and power (CHP) via municipal facilities (Weidner & Metz, 2008; Allen et al., 2012). The implementation of energy activities was highly dependent on the degree of ownership or stake in the project by the municipal government.

2.5.5 Spatial development

The next theme in the literature concerned spatial development. Rae and Bradley (2012) noted that energy autonomy could exist at different scales depending on the degree of separation with its surroundings and resources. The articles encompassed a variety of spatial scales ranging from individual or collections of energy autonomous buildings to towns, regions, islands or even entire countries.

At the smallest scale, researchers focused on individual buildings as grid connected or as off-grid power plants in their own right. The literature revealed a variety of concepts in relation to renewable energy self-sufficiency in new or renovated buildings. These included positive power (Krajačić et al., 2011), net energy neutral or energy negative (Rae & Bradley, 2012), near zero or zero energy (ZEB) (Dall'O et al 2013), net zero energy (Sartori et al., 2012) or zero carbon (McLeod, Hopfe & Rezgui, 2012). Such concepts have been embraced by a number of towns and cities. In the United Kingdom, the Zero Carbon Home program encourages Zero Energy Buildings (ZEBs) based on on-site, near-site and off-site renewable energy, and allows for other options such as investment in local energy infrastructure and the finance of energy efficiency renovation of buildings (McLeod et al., 2012). In Milan, ZEBs have been promoted through a certification scheme developed by the provincial government in cooperation with the local builders association and the Politecnico di Milano (Dall'O et al., 2013). In Australia, the net zero energy housing development of Lochiel Park Green Village in South Australia, a project based on the highest energy standards for building envelopes, appliances, solar electricity, solar hot water, smart meters and community development, have been driven by national and state legislation (Saman, 2013). Overall in Europe, the impetus to develop ZEBs is further motivated by the 2010 European Union (EU) Directive 31, Article 9 "Nearly zero energy buildings" which stipulates that new and existing public buildings should be near ZEBs by 2018 and that all *new* buildings should be near ZEBs by 2020.

Several studies however noted limitations when pursuing the zero energy or zero carbon goals. When the Department for Communities and Local Government in the United Kingdom consulted its construction industry, the zero carbon target was deemed unachievable for 10-80% of new homes due to cost. They argued that it meant preferencing greenfield sites over urban brownfields as the larger greenfields would be able to acommodate more buildings (McLeod et al., 2012). Others insisted that the zero carbon target would also require setting *minimum* energy efficiency requirements and a hierarchy of RES options (Sartori et al., 2012; Saman, 2013). Furthermore, storage, flexible production, and demand response becomes critical as autonomous systems become even smaller, while building location becomes decisive as those built in rural areas may result in increased energy demand for transport, partially offsetting energy savings from the buildings themselves (IPCC, 2011).

Following ZEBs, the energy region was the next spatial typology addressed in the energy autonomy literature (Späth & Rohracher, 2010; Müller et al., 2011; Schmidt et al., 2012; Weidner & Metz, 2008). Largely European-based research, the Germanic bias may be attributed to a strong tradition for independence and self-sufficiency, and the growing the number of communities that have already achieved energy autonomy, or on their way to reaching the goal, in Germany and Austria. Literature on the 100% renewable region tended to focus on strategic stakeholder and community mobilisation, planning and awareness raising. The motivations, perceptions, and fears were understood through workshops comprising local and regional parties. At this level, the region was seen to be the "best" spatial scale to achieve energy autonomy (Schmidt et al., 2012), with sufficient geographical proportion of urban to rural areas. However, Müller et al., (2011) noted that at the scale of the region, there is a risk of "potentially [allowing] for the exploitation of fossil energy resources such as oil, gas, coal or peat found within the region" (p. 5802).

The island was the next spatial type. Indeed, the growing number of islands around the world that are aiming towards 100% renewable energy self-sufficiency is not incidental. There is a prevailing need to curb the dependence on expensive fossil-fuel imports and sever the weak connections with mainland energy grids. As areas that will face the direct brunt of rising sea levels due to climate change, collective efforts to manage such environmental and socio-economic changes will become more pressing. For the islands, the challenges were geographically, demographically and politically determined. For example, how to duplicate energy models to other island conditions with different energy resources (Mason et al., 2010; Liu & Wu, 2010), how to cooperate with the local energy industries (Liu & Wu, 2010), how to source regional help to implement projects rather than depend on national policy, and how to face future possible cuts in subsidies, population growth and the lack of local energy planning codes (Praene et al., 2012). In the last instance for example, the island of Reunion was able to mobilise its Regional Council to create its own program for renewable energy technologies, supply management and energy monitoring. It also set up new local building standards with high energy and thermal specifications that were adapted to the climate, a regulation that was previously lacking. For Reunion and for many other islands, the overall concern became how to respond to a population growth rate that was higher than the rate of renewable energy technology installation (Praene et al., 2012).

At an even larger scale, countries were shown to be also adopting or considering the 100% renewable energy vision in the transformation of existing energy systems. According to the studies, challenges for these systems were shown to be mostly optimisation-related, such as how much of the energy resources can be exploited before they impact on land availability and use, for example windpower in coastal areas and biomass in farming areas (Lund & Mathiesen, 2009; Mathiesen et al., 2011, 2012), how energy efficiencies can be maximised in order to ease renewable energy integration (Ćosić et al., 2012), how to implement smart energy storage (Krajačić et al., 2011a), and how to deploy more sophisticated energy balancing systems that calculates on an hourly basis, since demand is usually focused at certain small periods during the day (Krajačić et al., 2011b). The main differences between the systems and island research lie in the geographical limits and the available access to the latest technological improvements.

2.6 Research methods

The research methods showed a tendency for quantitative techniques over qualitative methods, sophisticated energy systems modelling over surveys and interviews. Energy models were presented as alternative energy scenarios aimed at policy-makers to ease decision-making, assess the impact of energy policies, and act as an alternative world-view. Interviews and reviews, which were few, aimed at understanding stakeholder perception and knowledge, and more likely involved politicians, planners and other leaders rather than the general community.

Researchers usually employed a range of computer modelling tools including cost-benefit modelling (Zhang & Fu, 2011), geographical modelling (Schmidt et al., 2012), systems infrastructure modelling (Mathiesen et al., 2011; Krajačić et al., 2011) and financial modelling (Colmenar-Santos et al., 2012).

Generally, renewable energy potentials modelling figured in most of the literature on 100% renewable energy *systems*, and was dominated by the EnergyPLAN modelling tool, which simulates the 100% scenario for entire countries (Lund & Mathiesen, 2009; Connolly et al., 2011; Krajačić et al. 2011a; Mathiesen et al., 2011, 2012; Ćosić et al., 2012). The EnergyPLAN simulates the scenario by balancing electricity supply and demand in all sectors. It assesses the impact hour-by-hour, according to the simultaneous aspects of energy demand, consumption, distribution, costs, storage, production, regulation and technology capacity. First developed in cooperation with Denmark's Association of Engineers, it has since 2006, become the basis of Denmark's national energy policy. Similar to EnergyPLAN, H2RES is another model used to assess various types of energy storage for increasing renewable energy integration into existing energy systems. This is followed by the simple analysis tool HOMER. Used to assess systems on 100% renewable *islands* (Giatrakos et al., 2009), HOMER is a micropower optimisation model that plans for small energy systems that are either offgrid or grid-connected, and considers the energy mix, supply management and least cost planning. Another numerical model (unnamed) employed by Mason et al. (2010) simulates electricity production from RES that displaces fossil electricity production, based on a historic year data set.

In most of the systems (country) and island studies, scenario comparisons were the major means to differentiate between the effects of various local factors. Normally presented with three alternate scenarios, starting with the reference scenario (usually known as business-as-usual), a transition scenario (usually with compromised targets) and an optimum scenario (always 100% renewable energy), this process allowed the testing of various criteria critical to policy and project implementation. As noted earlier, these systems simultaneously considered a mix of RES, which is suited to the local context. Only a few studies focused on specific impacts of the 100% renewable energy system, such as the analysis of health costs, commercial potential, job creation (Lund & Mathiesen, 2009; Mathiesen et al., 2011, 2012), or energy storage (Krajačić et al., 2011a).

Qualitative research has been relatively few. These mainly focused on literary reviews (Hiremath, Shikha & Ravindranath, 2007; Rae & Bradley, 2012), energy policies (Weidner & Metz, 2008; Andrade et al., 2011; Praene et al., 2012), socio-political discourse (Späth & Rohracher, 2010; Kunze & Busch, 2011; Hauber & Ruppert-Winkel, 2012; Allen et al., 2012), or socio-economic analysis (Liu & Wu, 2010). Several researchers noted the need for further qualitative research.

Müller et al. (2011) noted that so far, research has not sufficiently analysed the factors behind successful projects, empirically compared communities that are 100% renewable, analysed decision-making processes, compared energy autarky with previous methods, or analysed the impact of duplicating the 100% renewable energy vision in developing countries. Rae and Bradley (2012) highlighted the need for further research into social, political and regulatory impacts, even though demand side management was argued to require particular attention. Sperling et al. (2011) argued for further discussion on the design of political processes to enable municipal energy plans in Denmark to match and implement the Danish 100% renewable energy vision.

It must be noted that omissions and assumptions may have impacted the accuracy of research. In the calculation of a net zero energy building for example, McLeod et al. (2012) noted that it was very common that criteria such as operational energy consumption, climate, comfort, performance and spatial usefulness were left out. For example, commercial interests can dictate results by calculating only thermal or electricity energy or placing over-sized photovoltaic systems on inefficient buildings. Additionally, literature on rural areas usually do not key in environmental factors such as land degradation, loss of forests, air pollution or biodiversity loss (Schmidt et al., 2012). And although researchers utilising the EnergyPLAN model recognised that future energy demand would most likely rise, energy demands and energy efficiency measures were still assumed to remain the same even in the simulation of future scenarios. It was also conceded that the most optimal combination of renewable energy technologies was often not chosen (Connolly et al., 2011; Krajačić et al., 2011b). Least cost planning analyses were admittedly not completely accurate due to an inherent bias towards using the cheapest renewable energy technology, which may not be as cost-efficient in the long-run as the more expensive technologies (Giatrakos et al., 2009). In addition, socio-economic benefits rarely served as one of the calculated criteria (Giatrakos et al., 2009; Mason et al., 2010) such as determining how local renewable energy can support local industries or improve an island's image or competitiveness (Liu & Wu, 2010). Finally, most of the research did not consider the effects of grey energy, which is energy embodied in the production, delivery, operation and servicing.

2.7 Discussion

2.7.1 Response to Research Question 1

Research Question 1 as formulated in Chapter 1 stated:

'As background to this study, what is the state of research into governing local urban development with regards to energy autonomy?'

An online search of the peer-reviewed articles revealed that there was indeed very few published (n=25) on this topic, affirming my first hypothesis of their rarity. It was found that the relevant peer-reviewed articles mostly appeared only in the last ten years (2003-2013). Those that touched on this topic tended to focus on semantic/conceptual discussions or analyses of alternative futures, demonstrating a bias towards either studies into energy potentials modelling and scenario simulation, or perception and acceptance analyses for energy autonomy.

One half of the articles tended to dwell on clarifying the term's meaning and relevance. Operating at a level of discourse that was quite abstract, these were generally more programmatic than target-oriented. The other half tended to focus on developing alternative future scenarios with a 100% renewable energy scenario as the ultimate goal. Via sophisticated computer modelling, these would assess such aspects as the economic costs and benefits of energy autonomous systems, the balancing of energy supply and demand that facilitates renewable energy integration, and the impacts of regulatory frameworks and standards on 100% renewable energy scenarios. These studies were however based on simulations and were largely theoretical.

In terms of urban development measures in energy autonomy, these were generally discussed in relation to the national government's role in providing better regulatory frameworks and incentives to guide energy efficiency and renewable energy integration in urban development at the local level. Local authorities do figure in the discussion but only in the context of being carriers and interpreters of the national message in energy and sustainability. Indeed, centralised intervention tended to dominate the literature, a reflection perhaps of the perceived scale of energy production required when pursuing energy autonomy, only capably handled and resourced by institutions of a larger size. Subsequently, this may have influenced the willingness of researchers to pursue analyses of local government. Local measures in energy autonomy were still discussed, but those cited were mostly restricted to building types (e.g. ZEB), infrastructural improvements or transportation fuels. There were discussions concerning planning processes required for renewable energy installations and zero-carbon buildings or housing, but no discussions for example, on area planning or masterplanning that optimises energy autonomy at the neighbourhood or urban level.

In relation to RES, the available literature on energy autonomy revealed that biomass was most commonly cited, primarily discussed in the context of rural energy (15 out of 25 articles). Although other forms of RES that form part of the mix required to achieve energy autonomy were also accounted for and analysed, these did not receive as much attention compared to biomass within the peer-reviewed research. One could argue that the immense availability of biomass in rural areas, and its proven track record in powering and heating areas through CHP and district heating networks within both urban and rural areas have rendered research into this area obvious and therefore credible. Conversely, one could argue that the bias towards biomass and rural energy also reflects the lack of research into renewable energy integration and potential of *urban* areas to achieve energy autonomy. It is a focus area, which could have highlighted the equally important role of other renewable energy sources such as solar photovoltaics, wind energy, heat pumps and geothermal energy in towns and cities. Although researchers have acknowledged that there are difficulties relating to land-use conflicts and space competition, there was very little discussion as to how to tackle these conflicts.

Indeed, half of the literature reviewed tended to focus on individual renewable energy sources such as biomass, photovoltaics, hydropower or wind power, discussed in relation to their specific spatial and environmental requirements. However, one could argue that this may be attributed to the scope and the availability of resources in support of the research work itself. A comprehensive analysis of all the available renewable energy resources and their impacts would have required a substantial amount of time, effort and resources. The articles that focused squarely on 100% renewable energy systems and which analysed the integration of a whole range of renewable energy sources, largely benefited from the computing modelling program EnergyPLAN, which was developed and run by 1600 experts (Lund & Mathiesen, 2009).

From the available literature, the idea of energy autonomy in the context of the municipality was seldom discussed in terms of local governance in a qualitative manner, besides brief descriptions of planning policies and programs. The outcome (that is, to reach the target) took precedent over the process for pursuing energy autonomy. The mostly quantitative work in form of energy modelling sought to inform local decision-making by providing vast amounts of empirical data and thereby give credence to the pursuit of energy autonomy, but the following steps in making sense of the data was not explored. Indeed, the choice of research method has restricted studies in energy autonomy to two main areas: quantitative modelling (theoretical) and qualitative reporting (historical). This has resulted in either pure sets of figures that confirm the possibility of energy autonomy, or reflective studies that critique past policies and actions. All of which did not seek to *plan* for the implementation of energy autonomy, or analyse what the vision would mean for those in charge. Interestingly, a few researchers have conceded that more studies is therefore required into analysing the legal or socio-political ramifications, since most admitted that this aspect is actually taking precedence over even economic, environmental or technical concerns.

Although this literature review only focused on peer-reviewed articles, it should be noted that there is a large amount of *unpublished*, unreviewed literature in form of magazine articles, reports and dissertations. These and others were not included here to avoid diminishing the qualified understanding of the topic and to maintain analytical rigor. Several German studies demonstrating the positive impact of energy autonomy on local or regional value creation or capture

(Wertschöpfung) (Salecki, Aretz, Hirschl & Prahl, 2012; Weiß et al., 2012; Hirschl, Heinbach, Aretz & Salecki, 2012) were for instance omitted from the final review, but they were still useful as background information in the context of this dissertation. Similarly, books by Herman Scheer and Peter Droege on energy autonomy have provided salient context to this dissertation. However since these were not considered peer-reviewed in the sense of undergoing rigorous review by fellow scientists and academics, they were not included within the total list of articles on energy autonomy.

Overall, the literature review showed that the research 'gap' rested in analysing the role of municipalities to implement energy autonomy through urban development. Potentials calculations have been done, renewable energy technologies have been identified, relevant actors have been ascertained, financial impacts have been reviewed, environmental effects have been better understood, and local energy concepts have been developed. However, the next step is to define the *process* that local governments can take to **operationalise concepts for energy autonomy** by tying all of the pertinent factors into the one process. Figure 11 shows the research 'gap' in governing implementation for energy autonomy, or as I label **operational governance**. I define this as relating to an outcome or implementation oriented government agenda designed, in this case, to transform the communal energy base. In this sense, it ranges from outcome-oriented policy and tools, to implementation and monitoring activities.

It is also important to note that the literature review provided some pertinent messages. To practically implement local energy autonomy requires: defining energy autonomy as a practical and beneficial vision in the form of local benefits *particular* to the local context, creating socially integrated and incentivised frameworks for increasing local renewable energy production and acceptance, addressing land-use competition and other conflicts, devolving powers to local government to create their own energy policies that are statutory, enabling municipalities to participate in the development of national energy policies, and adapting traditional planning cultures and approaches that moves towards energy autonomy at various spatial scales. Overall, it did not concern a universal approach to achieving local energy autonomy as previously assumed, but a more targeted approach towards expressing the social, economic and environmental values of energy autonomy for that locality.

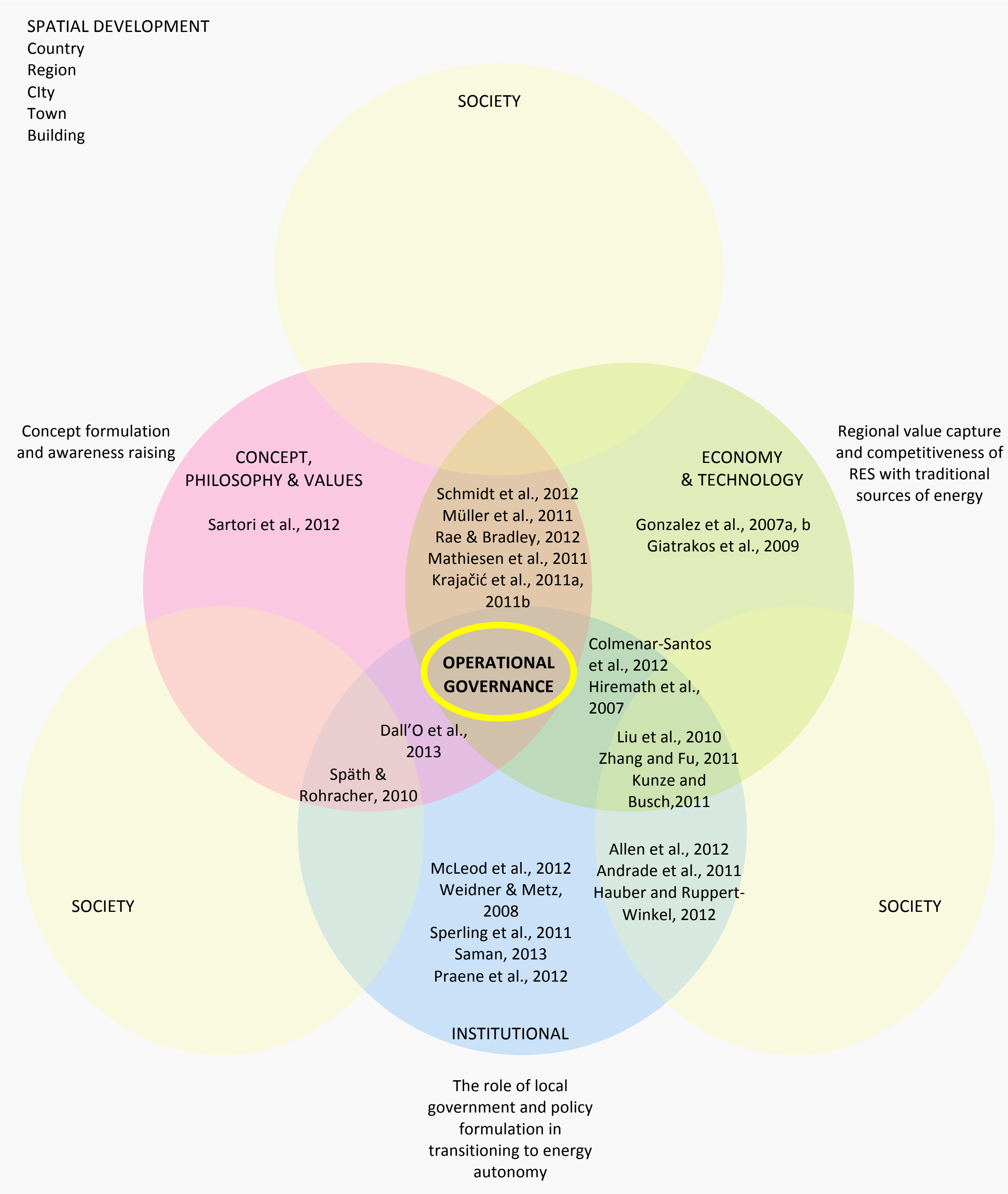


Fig. 11. The energy autonomy literature located within its intersecting themes, and the central research 'gap': operational governance.

Chapter 3. Expert attitudes

This chapter discusses the concept of energy autonomy and its pursuit at the local level, based on a survey of international experts from the fields of urban planning, architecture, governance and energy. The findings of this work serve to construct a framework for local government to realise local energy supply autonomy potentials. The effort has been triggered and informed by the application of modelling and mapping tools depicting the local self-sufficiency or autonomy potential of a local government area, based on spatially typological quantified energy demand, efficiency improvement and local renewable supply scenarios for that area. The survey reviews ideas for and attitudes towards realising this technical and theoretical capacity for direct autonomy through local governance, with a special emphasis on urban development.

The two-stage survey was carried out in 2011 to ascertain the most critical issues for local government and planning practice when pursuing energy autonomy. It examined the nature and the extent of local government intervention, and the efficacy of energy modelling to inform decisions in pursuit of this goal. This chapter presents the response statistics, expert comments, observations and conclusions. Questions were in part informed by the measures developed by Droege et al. (2010), as part of their ‘Urban renewable power policy toolbox’ for 100% renewable energy communities.

3.1 Context

Accelerating climate change is triggered by rising anthropogenic carbon emissions, with Europe recently declared to be at the brink of disaster (European Environment Agency [EEA], 2012). Climate change continues to be caused to a large extent by fossil fuel burning, source of 85% of commercial energy worldwide (US Energy Information Administration [USEIA], 2006; Boden, Marland, & Andres, 2009). Also, fossil fuel supply risks - notably the spectre of 'Peak Oil' - are rising, with evidence that the production of conventional oil has already peaked in 2006 (IEA, 2009). The case for 'decarbonizing' or 'defossilizing' economies and communities is well established, and the move towards a renewable energy based development paradigm is vigorously pursued across Europe and elsewhere - although not nearly fast and comprehensively enough (UNEP, 2012). This transformation is also seen to boost energy security since many if not most countries and regions are net energy importers today. Switzerland, for example, imports 80% of its primary energy, for example in the form of oil, uranium and electricity from coal (Bundesamt für Energie, 2011). For Liechtenstein, this figure is more than 90% (Droege et al., 2012).

In response to such risks, a number of regions, cities and local communities have implemented initiatives to facilitate the generation, distribution and uptake of renewable energy within local and regional boundaries, with the goal of achieving renewable energy self-reliance, or so-called 100% renewable regions or communities. Some are still moving towards this goal, while others have already largely achieved it. Examples are the island of Samsø and the commune of Thisted in Denmark, and Güssing and Mureck in Austria. Some larger cities such as Munich, Germany, pursue broader comprehensive carbon neutrality policies, extending their reach well beyond their boundaries. Other examples include the Transition Town movement of the United Kingdom and United States. In the wake of these movements, new local planning tools have emerged to model local governments’ capacity to local renewable energy independence. Such models have been advanced and tailored for the Principality of Liechtenstein, as well as the Lake Constance Alpine Rhine Region described below, demonstrating the capacity for local and regional energy autonomy.

This chapter is positioned to help answer questions that are central to the transition to energy autonomous communities. It aims at two distinct but related questions:

1. What measures local government can take to achieve renewable energy autonomy?
2. What attributes local energy autonomy modelling tools should have in order to be useful towards achieving this goal?

The surveys then address the following research question, as formulated in Chapter 1:

‘Research Question 2 In relation to implementation, what requirements should be most critically considered with respect to governing urban development for local energy autonomy?’

3.1.1 The regional energy autonomy research program BAER

It should be reminded that the Lake Constance - Alpine Rhine Valley Energy Region (Bodensee-Alpenrhein Energieregion - BAER) research project forms the basis of investigation in this chapter. BAER is a cooperative research project in the areas of renewable energy, sustainable development and the broad mitigation of regional climate change and energy risks. Explanatory notes on the research program can be found in Chapter 1, Section 1.1.1.

3.1.2 The space type energy model (STEM)

The energy modelling program on which the survey is based is the 'space type energy model’ or STEM, which was adopted and further developed in the BAER project. STEM uses a geographic information system (GIS) platform to calculate and map all local renewable energy sources, the efficiency gains possible and the local energy autonomy capacity in various scenarios and time frames. An earlier version of the system is documented by the original developers in assessing urban energy potentials toward the use of 100% renewable energies, and demonstrating energy autonomy potentials for Wilhelmsburg in Hamburg, Germany and the Principality of Liechtenstein. In Chapter 1, Section 1.1.3 describes the application of STEM to Liechtenstein.

3.2 Approach

In order to determine the factors for analysing local urban development methods for pursuing energy autonomy, a two-stage survey of international experts was implemented. The survey was developed based on the Delphi method of enquiry. The method’s suitability with regards to its benefits and limitations is explained in Chapter 1, Section 1.4.2. The survey involved two rounds of questioning. The first round gathered responses on a variety of aspects in energy autonomy. These results were fed back to the experts who participated, accompanied with a follow-up set of questions in the second round that aimed to find a consensus on certain issues that were elaborated in the first. The survey brought together academics, government officials, and experts from non-governmental organizations and practitioners from private entities, with expertise in energy, governance, urban planning and architecture. Experts were asked to give their opinions and recommendations about particular criteria for governing local energy autonomy, based on their own personal experience and theoretical knowledge. The ‘Urban renewable power policy toolbox’ developed by Droege et al. (2010) was used to structure the criteria and questions. It should be noted that this toolbox revises and expands on earlier work on public policy enforcement and support measures available to local government (Schuster, de Monchaux, & Riley II, 1997).

The six factors of the 'Urban renewable power policy toolbox' include:

1. Regulation, legislation and standards
2. Incentives and disincentives
3. Corporate asset development and management
4. Institutional reform; improved strategic and general planning practices
5. Community action, industrial alliances, information and education
6. Fostering energy autonomy and biological carbon sequestration practices

After reviewing these six factors against other case study based measures and discussing them in working sessions with expert peers and advisors, I found that the categories related to 'municipal asset development and management', and 'energy autonomy and carbon sequestration fostering', were too targeted and potentially non-disagreeable to be included in the surveys. Dealing with own municipal assets is already well-established and an obvious focus of local government action or agendas and indeed are most advanced in that area. The major challenge in this dissertation is to deal with energy policy and independence of the community at large. Local government may focus on what they can do but not focus on energy autonomy that affects the entire community. Meanwhile, fostering energy autonomy and sequestration, is not included because it is a broad theme and beyond the scope of the dissertation. Including the two aspects would have doubled the number of questions to be asked and risked losing respondents in the process.

In the survey, the category 'community action, industrial alliances, information and education' was split into separate categories 'partnering' and 'information and education' in order to clearly distinguish the different factors associated with each of the two. The survey added an extra category 'Other' in order to allow experts to recommend measures of their own. (See Section 3.3.6 for the criteria).

The first survey examined the nature and extent of local government intervention to achieve energy autonomy and the efficacy of energy modelling programs as one of the many urban planning tools to support this goal. It also determined which aspects of local government and planning practice should be most critically considered. The second survey focused on 1) gathering any changes in opinion based on the results of the first survey and the clarification of terms: namely, energy autonomy and energy modelling; and 2) clarifying expert opinions on specific local government tools and organisational criteria.

3.3 First round results

3.3.1 Distribution of responses

The first round consisted of six questions, eliciting both multiple-choice and open-ended responses. The questions were divided into two categories: local energy capacity models and local government methods. Email requests were sent to 431 experts, inviting their participation to complete either an on-line or a PDF survey. The final survey response rate was 18% with 77 experts responding. Most experts came from Germany, United States and the United Kingdom and were mainly academics. Most experts (73%) declared that they have been involved in renewable energy programs at the local level.

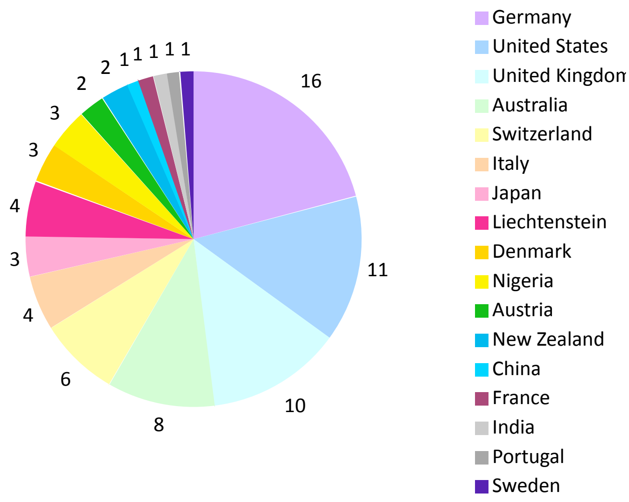


Fig. 12. Number of experts by country.

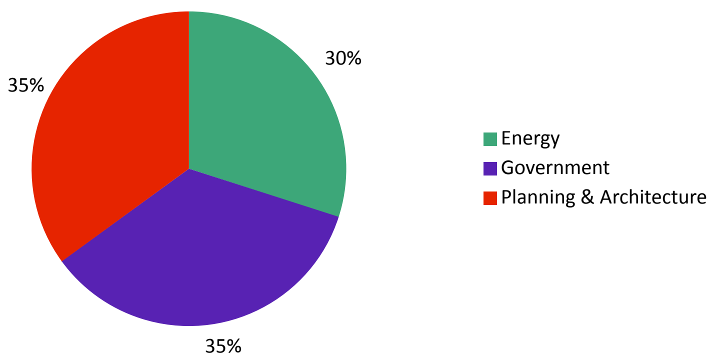


Fig. 13. Percentage of experts by profession.

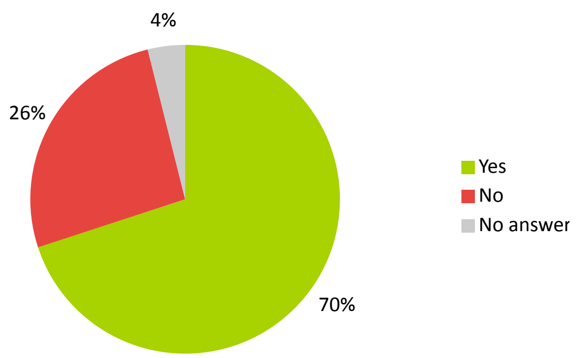


Fig. 14. Percentage of experts responding to the question: “Have you been personally involved in renewable energy programs at a community level?”

3.3.2 Question 1: Would energy capacity models boost local government energy improvement efforts?

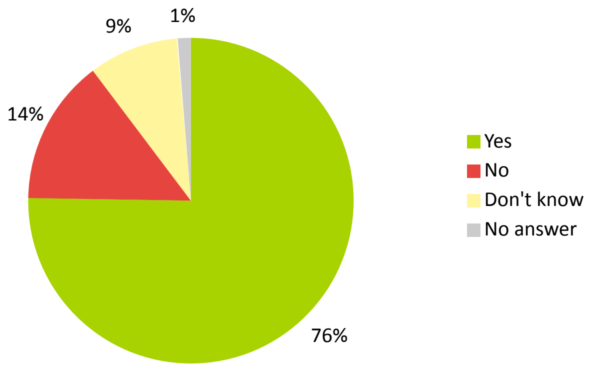


Fig. 15. Percentage of experts responding to the question: "Would energy models make a difference in boosting local government's energy efforts?"

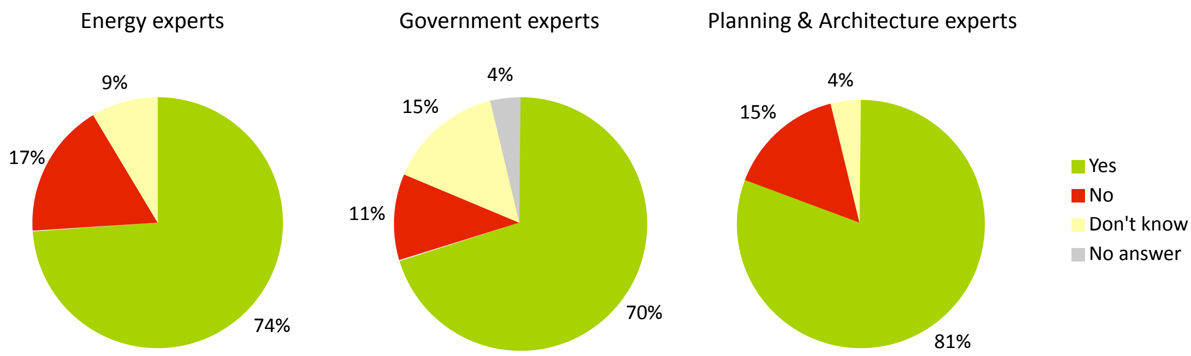


Fig. 16-17-18. Percentage of experts responding to Question 1 according to profession.

Most experts (76%) agreed that local energy potentials models such as STEM would make a difference in significantly boosting local government's energy improvement efforts. However, there was more uncertainty amongst government experts compared to experts in energy, or planning and architecture.

Expert Comments to Question 1

Many experts noted the advantages of local energy potentials models (n=15), in particular, their ability to assist rational decision-making in energy planning, and ability to visualise basic data and simulate different energy scenarios. Such models were admittedly useful for assessing the potential for renewable energy of an area, compare the different renewable energy options, and understand the contribution of each to meeting energy demands. They help set energy targets, outline corresponding measures, and monitor progress as the community move towards those targets. Visualising data in a manner, which is understandable to the wider community, helps ease community discussion and participation, inducing action based on the known energy savings and generation potentials. One planning expert from the UK cited the DECORUM model in the UK as one example of an energy model implemented with the aim to influence the retrofit of homes and businesses by instigating a type of peer pressure amongst all community sectors. The energy scenario maps generated also facilitated *municipal* debate and improved the 'buy-in' of broad-based support for the planning and implementation of energy programs, no matter the political affiliation.

Based on the experts' comments, the use of a local energy potentials model by local government however is dependent on a few factors: the principles or assumptions on which the energy model is based (n=7), the local government's knowledge of energy (n=4), and other issues that may impact its efficacy (n=19). For planning and government experts from Australia, suitable training of the energy model user, in this case the local government, is essential to ensure that they benefit from the energy model since "most local bureaucracies lack the fundamental skill base to even know what to do if good information or energy modelling where available". One US planning expert noted that local government usually have little to no knowledge about energy, especially renewable energy. According to one Nigerian energy expert, they are even "often unaware of the energy resources and the potentials of such [renewable] resources for use as fuels and generation of electricity for the sustainable socio-economic development of their communities". There is also the prevailing attitude that energy modelling is not usually considered the business of local government administration, a belief also expressed by the government and planning experts from Australia.

An energy potentials model, according to planning and government experts, is primarily about information; that is, it merely "gives local authorities access to information about what could be done in their local area if [and assuming] institutions, markets, were appropriately aligned", argued one UK energy expert. This means that the presence of energy models does not guarantee local energy improvement efforts. "It could only boost their effectiveness and outcome", argued one Swiss government expert. The energy model according to one UK planning expert is also really "just an abstraction of reality, which require a range of assumptions and selections to be made. When using such representations for decision-making purposes it is important to be aware and actively think of their political, symbolic or discursive significance at every stage of the process".

Despite the latest information derived from sophisticated energy modelling techniques, local government action is not necessarily directed in the right way, argued one Austrian planning expert. In the city of Boulder, United States for instance, a study completed on the localization of the city's renewable energy supply did not result in any action despite a complete assessment of what was possible and most economical in terms of the solar, wind, hydro and geothermal potential, reported by one of its former government officials.

"Academics should not assume that practitioners are waiting for the next great energy model, as a basis to act. Often what they want is continuity with their existing work practices", argued one UK planning expert. Many may "not want to change horses in midstream because a new model may not show the same improvement in their progress figures". What would be more critical is to increase the knowledge and determination of the people to pursue energy-efficiency and local renewable energy. According to one UK energy expert, "once the determination exists, it is more likely that representatives with the same opinion are elected to national and local government". Associated with this is a willingness to change lifestyles through education, institutional methods and active demonstrations in transport, housing and energy generation. The use of energy models as a tool to optimise would only then follow.

Misinterpretations are possible. This is reflected in the view of one Swiss planning expert who maintained that in the context of the Swiss Energy City programs, the proposed energy potentials model (STEM) implies a certain inadequacy in current energy programs. (It should be noted that in this dissertation, STEM serves mainly as energy modelling tool that calculates energy demand, efficiency and generation potentials, based on known data for a given area, and does not carry any value judgements in relation to the efficacy of other evaluation frameworks).

This misunderstanding was also reflected in the criticism regarding the term *energy autonomy*, particularly by two German government experts who queried about how all communities, especially large cities and industrial towns, could possibly achieve this target. They argued that not every municipality has the capability, capacity or resource to reach energy autonomy. “Could the municipality rely on surrounding municipalities, rural areas or on off-shore facilities?” asked one expert. “Is energy autonomy based on the calculated mean average per year or a real time calculation at each minute of the year?” asked another. It was clear that the concept was still undefined for several experts.

Although local energy scenario maps developed by local government through energy modelling may provide the community with new and interesting information on the efficiency and energy generation potentials of their locality, experts argued that it is also uncertain as to whether such maps will be readily accepted or correctly interpreted. It will moreover depend on the public’s level of trust in local authorities. According to one UK planning expert, there is growing evidence in the UK of a decline of trust towards institutions such as central and local government, politicians, businesses and the media. This will impact the way energy data is read and perceived by the community, thereby impacting the way energy data is selected, translated and represented by the municipality.

Other experts queried the effectiveness of energy models to actually pursue energy autonomy (n=17). Many European government experts noted that it is not actually a question of technique or more and better information but really a matter of attitude and moral and ethical responsibility of decision-makers and the rest of the community. One German energy expert declared that virtually all energy autonomy projects in Germany have been based on a few, motivated and really committed persons. Energy autonomy ultimately required strong political will (n=5). In Canada, the moderate success of local programs was not due to the lack of instruments but the political will and budget to make progress, remarked one government expert from Canada. In Switzerland, the moderate progress in renewable energy development compared to some of the achieved goals (for example, in mobility) was also due to the lack of strong political commitment, noted one Swiss government expert.

But strong political will is difficult in the light of the lack of powers to govern energy. Compared to other experts, those in government tended to highlight the general lack of *authoritative* capacity for local government to develop and implement energy projects. In Australia for example, local government was described as largely “disempowered, lacking the autonomy, confidence and political leadership on energy”. This was reiterated by one expert from the United Nations, who declared that “the vast majority of local governments in the world play a very passive role in energy policies and practices. They have virtually no say in, for example, energy pricing and grid management”.

For others, the problem of switching to renewable energy was argued to be more to do with finance and politics, rather than space or capacity. Planning experts from the United States for example noted the need for improving the cost and availability of renewable energy. One government and energy expert from Denmark argued for a significant increase in national support for local government budgets in order to finance local renewable energy projects. One government expert from Nigeria noted that in the case of communities in Africa, de-carbonising programmes have been undertaken without any energy modelling facilities, since mapping and geo-information production and use has been poor. Existing energy supply and distribution networks, including the energy markets were actually greater barriers. Indeed, measures that address alternatives to the incumbent fossil or nuclear energy systems are usually treated with little respect. According to one United Nations expert, “the fossil fuel lobby for instance has been so dominant that it does not allow any alternative energy system to compete with petroleum. Any energy program that questions the reliance on fossil fuel is not taken seriously”.

Despite the limitations, there were many suggestions as to how local energy potentials model could be improved (n=18). These, according to the experts, would primarily relate to: integrating future attributes (n=9), and improving the user-friendliness of the energy model (n=9).

Additional attributes may account for energy costs savings, renewable energy infrastructure efficiencies, local economic value creation, local job creation, market influences, policy impacts, landscape impacts and energy-consumptive behaviours. (It is interesting to note that the German experts tended to prescribe more economic-oriented attributes compared to others.) For one Australian architect, calculations of existing floor space and other building characteristics including plant equipment and fabric performance that allows future projections and better management and utilisation of renewable infrastructure would be ideal. The spatial distribution was also critical for the type of infrastructure installed, particularly for combined heat and power networks. Another essential attribute was to display the advantages of local energy supply over energy imports.

According to one German energy expert,

> “We need to integrate not just the pure generation costs of renewable energy installations, the electricity grid use or other transport costs, but all the factors that intervene such as the value of energy at different times and market influence. In the future, not only single renewable energy installations are to be considered, but rather entire renewable energy generation-storage-use complexes such as virtual power plants/systems (VPP/VPS). A particular point is the synergy effects that are only possible at local level, for example, combined heat and power generation or the use of heat for heating in winter and cooling in summer. Existing cost comparisons should also build on a mixture of local and global needs and effects. Energy models that will serve for decision makers at local level will have to clearly distinct between both components. They should also clearly display the dependency of costs as a function of parameters such as distance and density. For instance, there exists a critical distance up to which a decentralized solution is better than a central one, for example, the transport of straw makes only sense up to a distance of some 50 km. Sometimes there is not a critical distance, but a critical density, for example, a minimum heat demand density for local district heating”.

The impact of local, regional and national policies should also be integrated in the development of local energy potentials models, such as restrictions set by policies in regional planning, nature conservation and land-use for agriculture. And while knowing how much RES is available is critical, the user should also be informed of *what measures to implement where*, according to one Swiss government expert. In Switzerland, the Federal Office for Energy SFOE has modelled heat availability and demand on a map to provide a decision tool for district heating. Another attribute suggested was to visualise energy use over spatial areas as an effective way to demonstrate user behaviour, and in turn influence individual energy use. In Australia, the use of interactive smart meters in households within the Lochiel park development in Adelaide, South Australia facilitates immediate feedback to researchers and householders.

The overall consensus concerning energy models was that they should be easy to use, be easily understood and be accessible. The energy modelling results should not be proprietary or remain academic but function as a public tool that outlines the necessary measures such as financing plans (government expert) and links to existing programs such as the Energy City or European Energy Award® (energy expert). Several planning experts agreed that the energy model should include a high degree of interactivity and not be costly. Any further development and adaptation should involve the early participation of the municipality and other end users to which the energy model is directed.

Question 2: How are energy modelling tools best employed to achieve energy autonomy?

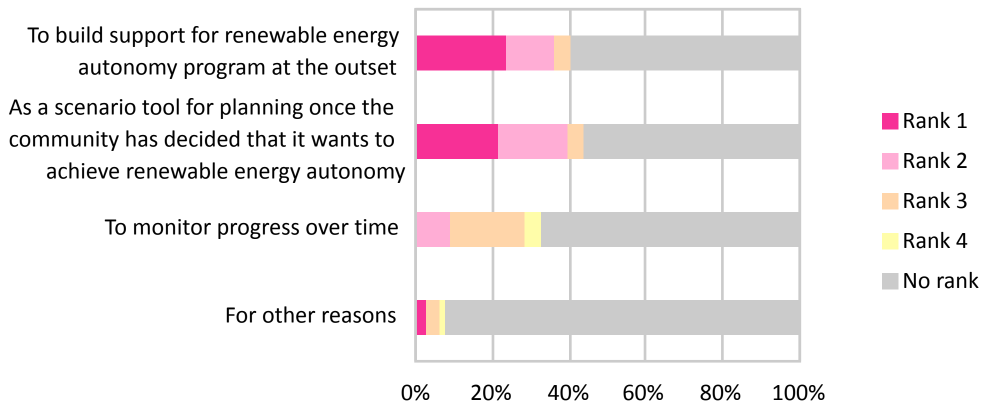
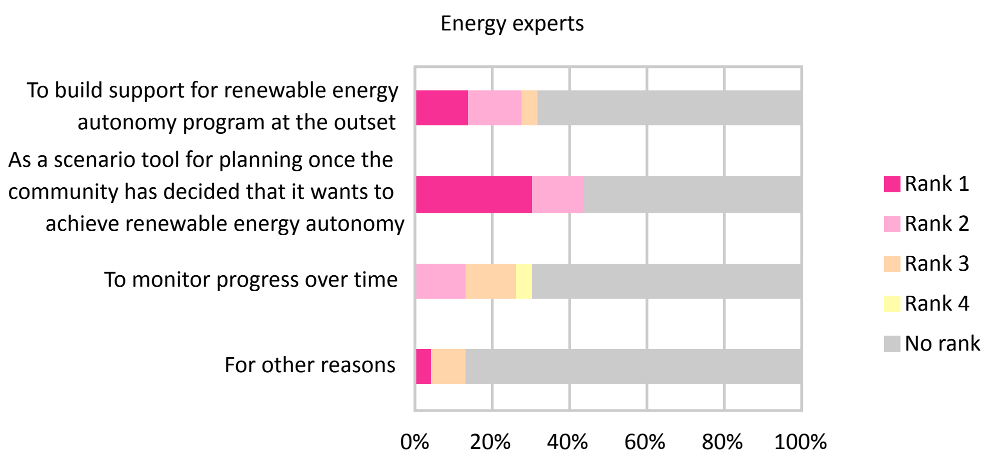
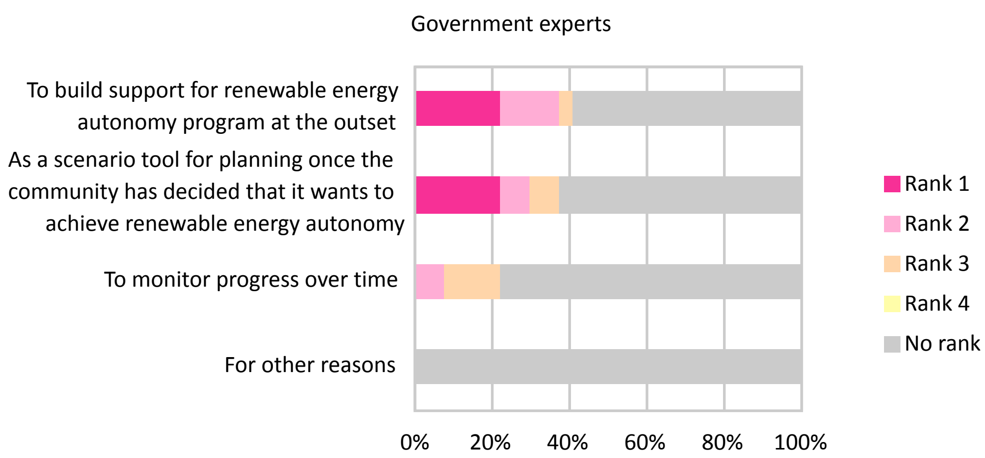


Fig. 19. Percentage of experts rating the best function for local energy potentials models.





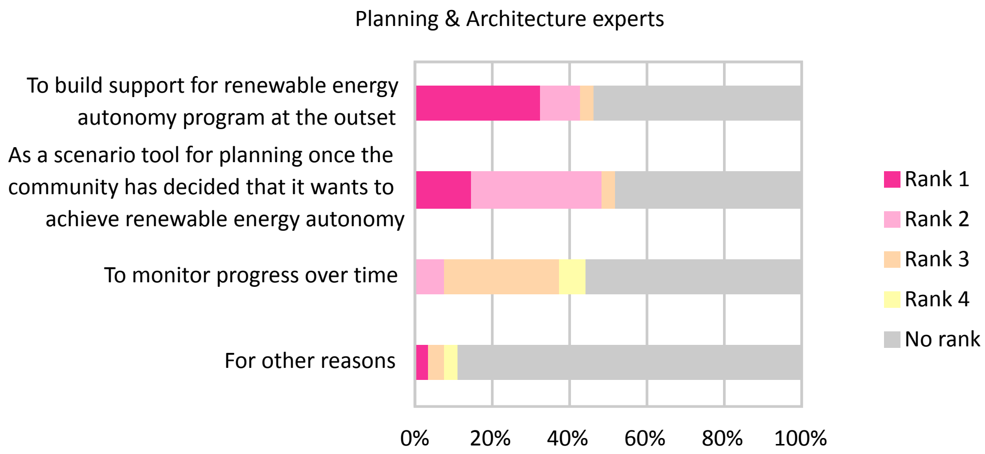


Fig. 20-21-22. Percentage of experts responding to Question 2 according to profession.

Most experts believed that local energy potentials models such as STEM would be best employed to build support for renewable energy autonomy from the outset. Experts in planning and architecture tended to emphasise its capacity for building awareness compared to energy experts who found its ability to formulate alternative scenarios for planning more significant. Interestingly, government experts viewed each of these two factors equally. The use of the model to monitor progress over time did not elicit strong responses; in fact other reasons often superseded it. These included helping to devise detailed energy infrastructure and upgrade programs and projects, create locally relevant metrics in addition to greenhouse gas emissions and fossil fuel reductions, stir several groups into coordinated action, sustain local participation, create competition between communities, mobilize funds for implementing the project, and assist in the development of a strategic plan.

Expert Comments to Question 2

When employing a local energy potentials model, experts argued that it should be economically relevant (n=8), time-conscious (n=14), and community oriented (n=23). A good energy model should be able to “chart a path to the future” and “assist in forward planning”. Based on comments, most planning experts supported its use to assist the formulation of strategic plans, and then to validate plans via scenario testing. In comparison, government experts emphasised the role of scenarios to first help compare the current position to the renewable energy potential, and then show how renewable energy autonomy might be possible.

According to one German government expert, the energy potentials model should overall demonstrate the economic, social and ecological impacts. It should accompany a community's development for the long-term by monitoring progress over time. It should serve as a driver of positive change and help maintain commitment and course. The energy model can “help kick-off’ projects”, “monitor continual improvement” and “prevent ‘slippage’ to former modes of practice,” argued other planning experts. For energy experts it is its “ability to refine projects”, “establish a hypothetical baseline against which actual progress can be measured,” or “calculate the state of implementation with the first estimate”. This can involve “the continuous adaptation of the initial scenario in line with the monitoring that takes into account new and better information about potentials and technology”, maintained one energy expert from Germany. Other experts noted its ability to “confirm benefits”, “help recalibrate existing models such as ISO14000” and “report success”. Moreover, the energy model reiterates the basic United Nations commitment whereby sustainable development outcomes should moreover be measurable, verifiable and reportable. According to one US government expert, “the encouragement gained by gauging progress is important to staying steadfast as a community”.

There was a general consensus that community engagement with the local energy potentials model is highly important (n=23). According to the government experts, the energy model should not be “solemnly local but involve the full attention of regional or national programs and be accessible to the rest of the community even if only a few choose to participate”. It should involve at least some community commitment through collaborative stakeholder engagement processes. One planning expert from the UK argued that only then can the community understand the extent of the issues involved and form a sense of ownership of the concept and pin-point the necessary actions. This also avoids local government action appearing to be ”duplicative to functions normally left to national regulators and/or markets”, stated one UK planning expert. Another energy expert from Germany asserted that the energy model moreover helps the community to make a first choice of possible measures, which can be part of a realization program towards energy autonomy. But for further development, “the cooperation of the relevant actors and stakeholders is absolutely necessary. Scenario tools cannot enforce this cooperation. But the scenario tools can help to illuminate different pathways to the potential cooperation partners.”

For several planning experts, an energy model can help increase acceptance (n=4) and “stir several groups into coordinated action”. It can dispel the prejudice that “there isn't enough renewable energy around. “Early buy-in is essential in community development of renewable energy”, argued one planning expert from the UK. “Once the initial ideas and options are agreed, the building of support will be essential even before any formal planning application is submitted”. However the energy model can only be useful if they reflect the reality that people experience. According to one US energy expert, “they should be able to be understood by the community and be adjusted for different audiences, if not they may be too simplistic to be of practical use during implementation”. Other experts noted that the energy model should be practical in the sense that it helps the planner to decide which technical energy solution suits their local community, building the case for different renewable energy applications and energy efficiency practices. According to one energy expert from Nigeria, an energy model that is interactive and transparent better allows all the stakeholders in the community to clearly see the available energy resources in their community, which can be exploited for their socio-economic well-being and industrial development.

The functionality of the energy model is however dependent on a variety of factors. According to experts in government and planning, the need for and success of a local energy model depends on local circumstances. What kind of information does the local government already have? What kind of instruments is already used? What are the budgetary constraints? What are the institutional constraints? According to one Italian planner and architect, other non-technical or physical barriers such as environmental impacts or economic sustainability come to play, aspects that are not easy to quantify. Each region or community government thus has to find the most appropriate way for achieving his or her own energy autonomy.

Moreover it also depends highly on the people themselves, that is “the movers on the ground who really push for such an option”. In Germany, one government expert stated, “scenarios are not well known at the local level, movers are often missing and local government incentives are often absent”. He gave the example of the German grid-contracting model, which although has achieved some level of renewable energy emergence, it has not really encouraged decentralised local solutions. Indeed, government experts tended to agree that the decision to move towards energy autonomy is ultimately a question of political motivation. Energy models can only play a role by strengthening the political goals and provide a degree of realism to ambitious goals.

Local energy potentials model should incorporate ways to express the costs-benefits of energy autonomy, particularly since local governments tend to target projects that are most cost-effective, according to one US energy expert. Meanwhile the rest of the community tends to follow plans that articulate the best economic gains for the community, argued another Danish energy expert. Financial assistance is more likely available for projects that demonstrate the best cost-efficiencies based on a clear energy strategy. Community action is more likely be achieved if energy models can show neighbourhood wide energy consumption patterns, argued one Australian planning expert. In this case, the motivating factor is

> "…to trigger the desire to be typical (that is, average) or to perform better than the neighbours by enabling the users to see the disparity between them. This could be useful way to kick-start a project and generate local enthusiasm for it".

However one government expert claims that "competing jurisdictions" can also be a disincentive or barrier:

> "Municipalities comprising a region most often than not pursue their respective political agendas, compete with one another for resources and investment, jobs and housing, grants and subsidies. The result: irrational land use, wasteful duplication of infrastructure and services, and urban sprawl. An energy model that can also model the effects on an entire region and help establish a strong regional framework that govern land use, infrastructure and services, mobility and energy, may be a stronger alternative".

3.3.3 Question 3: Is energy autonomy pursuable without major change to local government structure?

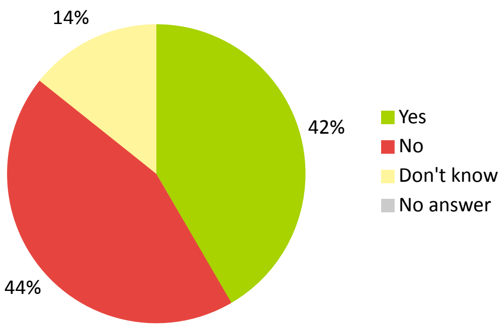


Fig. 23. Percentage of experts responding to the question: "Can energy autonomy be pursued without much change to local government structure?"

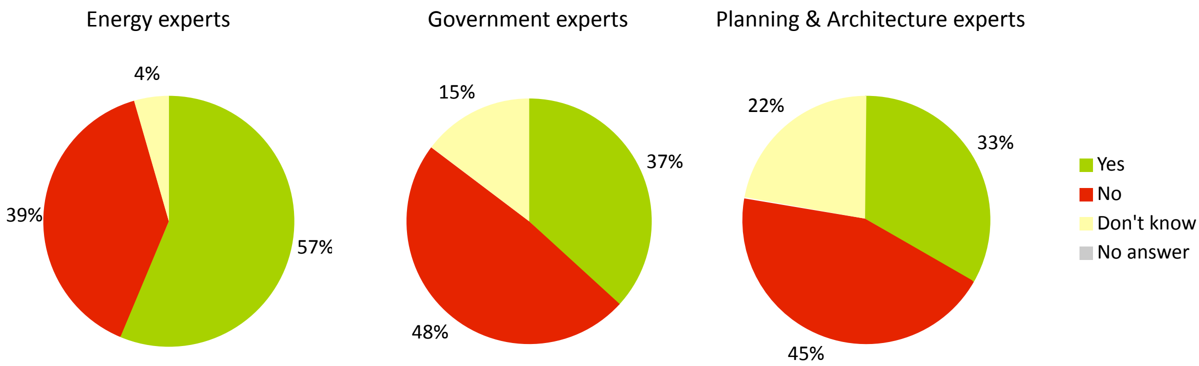


Fig. 24-25-26. Percentage of experts responding to Question 3 according to profession.

Experts were equally divided as to whether energy autonomy could be pursued without significant change to the local government structure. However, it was shown that experts in government, and planning and architecture tended to think that changes were necessary, compared to energy experts, who were generally more optimistic of existing methods and practices to pursue energy autonomy.

Expert Comments to Question 3

Experts who answered that no changes in local government structure were necessary recommended that existing municipal issues were addressed in order to achieve energy autonomy. These issues relate to administrative management (n=18), local ideology (n=13), regional or national assistance (n=11), public participation (n=14), and local electricity provision and transmission (n=9).

For the experts, the problem did not concern local government structure but rather governance aspects. According to one energy expert, the lack of coordination between the roles and responsibilities between the various local government entities with regards to energy will make the pursuit of energy autonomy difficult. Others noted that the quality of the people in government, their degree of awareness, knowledge and commitment, and their effectiveness as advocates will also be important factors. One Danish government expert argued that this alongside the allocation of resources for work in planning and dissemination for example would be more critical. The level of political autonomy already enjoyed is also a factor as one expert remarked that those “who already have significant autonomy could proceed far down the route with little structural change”.

The pursuit of energy autonomy by the administration concerns staff, leadership and empowerment according to several experts. Giving the example of Samsø in Denmark, one planning expert from the UK argued that the only ‘change’ required there was installing one or two planners dedicated to the process of energy autonomy, a change that was sufficient and effective. For one Australian government expert, the presence of local champions “both within and outside local government who are prepared to push the cause of renewables and energy efficiency” was important. As for devolving power to local government, several government experts asserted that administrators, particularly lower level officials should be empowered to make their own decisions related to energy (Japanese expert), that the decision-making process in energy be formalised (Canadian expert), and that energy as an issue be given greater political weight (Swiss expert). Local leaders should also at the same time, be willing to act, take risks and pursue innovations. These, in the case of Japan have been significant barriers, argued one Japanese energy expert.

Ideology is another significant factor that ought to be addressed. There was a consensus between government experts from Germany and Liechtenstein that to decide whether energy autonomy should be pursued relies much on the attitudes and moral/ethical responsibilities. “It is not a question of structure but a question of sensitivity, agenda setting and/or attitude”, declared the government expert from Liechtenstein. This attitudinal factor is interestingly reflected in the strong assertions by a few experts who believed that energy autonomy was neither “a useful real-world concept” nor “a necessary goal”. It is according to one government expert, a “utopian vision” that should only “at best … serve as one of many guides for more sustainable development”.

One Swiss planning expert argued that certain RES was not capable of meeting the energy demands to meet the energy demands of all communities, giving the example of hydropower in Switzerland which was argued to be inadequate for some while a surplus for others. Interestingly, the expert did not consider that energy exchanges between communities and RES distribution over a wide region forms the basis of energy autonomy. It is important to note that this particular expert also did not believe that communities really wished to pursue energy autonomy in the first place. Another government expert from the World Business Council for Sustainable Development (WBCSD) argued that “local energy autonomy actually serves as a disincentive for a region endowed with an ample supply of renewable energy (e.g. geothermal) to develop that source to its fullest potential”, in that the focus on the local would mean that the region as the more suitable development scale for energy autonomy would be undermined. Instead, what was really needed was a holistic approach to urban development, not just in energy demand and supply. It requires “fundamental changes in land-use planning, urban design, housing, transport and mobility, health and education, water and sanitation, pricing of public goods and services, labour laws and working hours”. For this expert, energy and energy autonomy were not exclusively the root of urban problems.

To pursue energy autonomy also requires re-addressing the role of local government. One German planning expert argued that although local governments in Germany are legally able to pursue energy autonomy, this goal and these activities do not have any tradition in the administration department structure. For one government expert in Australia, local government is instead typically concerned with “servicing”, rather than “strengthening”:

> “That is, it is often said, and disparagingly so, that the business of local government is 'roads, rates and rubbish'. However, there is an increasing pressure on local government business to concern itself with 'strengthening'. 'Strengthening' is typically associated with the future. That is, what can a local government authority invest in and develop to ensure that the future is more resilient? The business model around 'servicing' looks very different to the business model around 'strengthening'. Each has a fundamentally different investment risk profile (both political and financial), each requires very different skills capacities to reside in the organisation, and each requires very different corporate decision making and delivery structures to be present. Innovating the local economy to be underpinned by renewable energy sources requires local government in Australia to pursue a 'strengthening' business model in addition to its traditional 'servicing' mode”.

However, some experts argued that research should go beyond “blaming” local government attitudes, knowledge and practice. “Government consumption and efficiency is only a part of the overall lifestyle, not a major one”, argued one planning expert from India.

Still, there was agreement that a paradigm shift is necessary to pursue energy autonomy, with “effective action to contain the disastrous effect of climate change and the threats of peak oil and natural resource depletion”. There was a consensus amongst planning and government experts that current structures have been developed under a different paradigm that “did not necessarily take renewable energy into account” and which “emerged in response to a [centralised] industrial energy economy”. Subsequently according to one planning expert from India, “network decision-making or distributed responsibility or 'the wisdom of crowds' is not encoded in the way governments work today”, aspects necessary for managing a distributed renewable energy supply. Despite this, one architect and urban planner from Italy argued that the paradigm shift is slowly taking place, citing ‘The European Charter of Solar Energy in Architecture and Urban Planning’ (1996) and the European Directive on Zero Emission Energy Building, a document which has been signed by a league of committed European architects, urban planners and decision-makers to support the highest energy standards in sustainable architecture and urban design. Another similar charter can be found in the European Covenant of Mayors framework that has so far committed over 5000 mayors to increase energy efficiency and renewable energy use in towns and cities.

By making use of existing regional and national policies and structures, the need for local government changes can also be avoided. Most experts generally supported feed-in tariffs and other national subsidies for conversion of and connection to regional (smart) grids. However, local governments should take note of obstacles that may lie in higher-level ‘support’. Local authorities that are constrained by national legislation require structural barriers to be removed”, argued one UK energy expert, while “the balance of power between central and local government may also require changes”, remarked another planning expert from the UK. “Devolved responsibility for energy needs, modelling and network integrity/integration from national energy regulators to involve local governments would assist and as such be a change from current local government concerns”, declared one UK planning expert. Lobbying regional and national governments to pursue energy autonomy may also be necessary. One planning expert from the UK wrote:

> “Local government can play the role of advocate and lobbyist to influence decisions at higher levels of government. [They] should take the necessary research and planning steps to lay out a vision and quantification of energy that can be generated first locally, then through larger decarbonisations efforts at the regional and national scale”.

This re-alignment of power follows from the need for different levels of government to manage the different scales of renewable energy technologies. Some of the renewable technologies will rely on larger scale infrastructure for example to provide smoothing and storage, which may be difficult to implement at the community or city scale. Hence, assistance and cooperation between the community and the different levels of government are essential. One UK planning expert noted that in the case of Samsø, Denmark, work conducted with the local, regional and national governments helped local non-profit organization Samsø Energy Academy achieve 100% energy autonomy in the community in the establishment of local wind farms and district heating.

Public involvement can also supersede organisational change according to some experts. They agreed that it is the community that should really drive the change, where the creation of "an autonomous energy supply is an initiative of the people rather than of the government", declared one German energy expert. In the absence of this, energy autonomy may not happen even with changed governance structures. "Many of the energy activities will require public-private partnerships but the public portion will still need to lead in initial phases", argued one US planning expert. "Local input would enable the local authority to take into account differences in culture, society, economics and perceptions", according to one US planning expert. It would also "enable technology and energy conservation concepts to be embedded into the psyche of the community", argued another Australian expert in energy. A strategy to affect a community paradigm shift is essential according to one German energy expert:

> "only a few players, generally large conventional energy companies profit from *not* developing local energy autonomy, while many other players, essentially at the local level, profit from it [pursuing energy autonomy] – the perception of the latter is usually slow to achieve. Hence what is needed are a clear strategy, a consensual action plan, clarified responsibilities and distinguished leadership for coordination".

For public participation to succeed, protocols or standards of cooperation with stakeholders should be developed, argued several government experts.

There is potential to manage the local energy supply and distribution without the need for structural changes according to a few experts. One energy expert noted that in the UK, although local authorities usually have very limited options when it comes to transforming energy systems, a common response has been to create a municipal utility or community cooperative for local energy generation by establishing partnerships with businesses and residents. This has entailed very few changes at the local administration level beyond regulatory guidance. According to one energy expert from Germany, the rise of municipal utilities today suggests that "it is completely within government capacity to create and manage such an entity, avoiding the need for any major changes to the government structure – although it need not be a precondition to local energy generation and distribution". One expert cited Woking Borough Council in the UK, where a significant shift in practice and the development of a Municipal Energy Supply Company (MESCo), occurred within the existing local government structures. However governance practices may have to evolve in the future:

> "local authorities play major roles as employers, procurers of services and role models, and much can already be done. But generally, new models of financing, fiscal autonomy, regulatory frameworks (for example, governing energy supply companies) alongside knowledge and management skills will be required to enable local government to take the lead in energy autonomy, and to maintain this over time".

One German energy expert sums up the three essential aspects for existing structures to pursue: first, the clear assignation of responsibility for energy supply to local communities, second, the facilitation for local communities to get back control over electricity distribution grids, and lastly, the facilitation for local communities to impose connection to distribution grids for heat and power.

3.3.4 Question 4: What kind of organisational changes would be required to achieve energy autonomy?

Experts who considered that changes within local government structures were necessary, commonly referred to cross-departmental coordination (n=11) and other socio-technical adjustments (n=8).

Several experts noted that the disconnection and fragmentation between individual government departments has resulted in the discoordination between sectoral policies. According to one government expert from the World Business Council for Sustainable Development, local governments are generally not set up to work holistically. “To the contrary, they are budgeted, structured and managed according to sectors and act accordingly”. But to achieve energy autonomy, argued one German energy expert, requires:

> “…integrated planning processes regarding many different aspects of local government - from regional planning to economic development, planning of transport, local energy measures and the administration of locally owned buildings. Today most of these aspects are treated separately and communication between the different units of local governments is not sufficient. Hence a restructuring in the sense of greater policy co-ordination and co-operation across sectors and a whole of government approach to renewable energy becomes essential”.

According to one planning expert from the UK, this means, “integrating energy policy concerns within all other departments, increasing the transparency of decision-making and making sure it is as inclusive as possible”.

In policy terms, a common coordination plan between all energy related sectors is critical, asserted a few government experts, one of which remarked that “as long as each department is accountable to a distinct set of performance indicators and outcomes, energy policy will remain victim and hostage to sector-specific priorities”. Another important consideration is to establish bipartisan support and to take note of election cycles. According to one Danish government expert, “you need to cancel normal policy opinions and gather all political parties behind the ambition/vision and support this idea so there will not be a change in program if there is an election and therefore a change of policy”.

To facilitate cross-sector coordination, experts referred to the creation of project groups, local or regional energy agencies or energy departments. For new cross-sectional tasks, governments have tended to establish project groups, but according to one German planning expert, these “generally have less staff and after some time, are apt to lose interest and importance”. A better alternative argued experts was to establish local or regional agency that is given a management mandate. Best created in close collaboration with the public utility companies, the agency may be carried by one or a number of municipalities. A local government mandate is similarly reiterated by one energy expert from Nigeria who argued that all tiers of government that are involved in the supply stream of energy services, should be given the necessary powers to achieve the purpose of making modern energy services accessible and affordable to the local communities. (Interestingly, renewable energy is not specifically mentioned in this statement.) For this expert, energy issues should no longer be taken as the prerogative of the national or federal government, but become decentralised, both figuratively and conceptually. This expert goes on to also support the establishment of an energy department with qualified personnel within local government. Meanwhile, structures should not only have the capacity to coordinate across local sectors but also coordinate with higher-level frameworks. According to one German energy expert, the local organization should have the ability “to coordinate energy relevant questions, processes and planning at the local level, while at the same time, maintain contact with regional or higher governmental structures”.

In relation to socio-technical adjustments, experts referred to developing local governance structures that can facilitate the transition to a future decentralised energy system. This was the position of two

German energy experts. It is a position that would require "institutional innovation" (Japanese expert) and adjusted "modes of operating" in achieving local government "effectiveness, efficiency and transparency" (Australian expert). Other government experts noted also the essential presence of *qualified* personnel in local government for the implementation of relevant actions. It is claimed that changes in the local government structure is inevitable as more people becoming involved with work related to the energy area. Indeed the socio-technical changes need to be systemic and reflect the energy transition required to pursue energy autonomy. According to one architect and urban planner from Italy, it should reflect the total change of the current centralised energy model, its replacement with a new model based on decentralised and diffused renewable energy and the revision of urban planning and architectural rules to integrate new energy imperatives.

It is important to note that the changes discussed above are not prescriptive and depend very much on the individual countries and their local governments. According to one energy expert from Nigeria:

> "In the developed countries, significant change to the local government structure may not be necessary to attain energy autonomy because of the high level of literacy, strong, long and well established democratic governance, high technology dependent citizenry, better infrastructures, and high energy dependent economy. However, in the developing countries, many of which poverty level is high, illiteracy is high, democracy is either nascent or even non-existing, technology level is low, access to modern energy services is still low, significant change to the local government structure may be highly necessary to pursue energy autonomy."

3.3.5 Question 5: How do you rate Droege et al. (2010) measures for achieving energy autonomy?

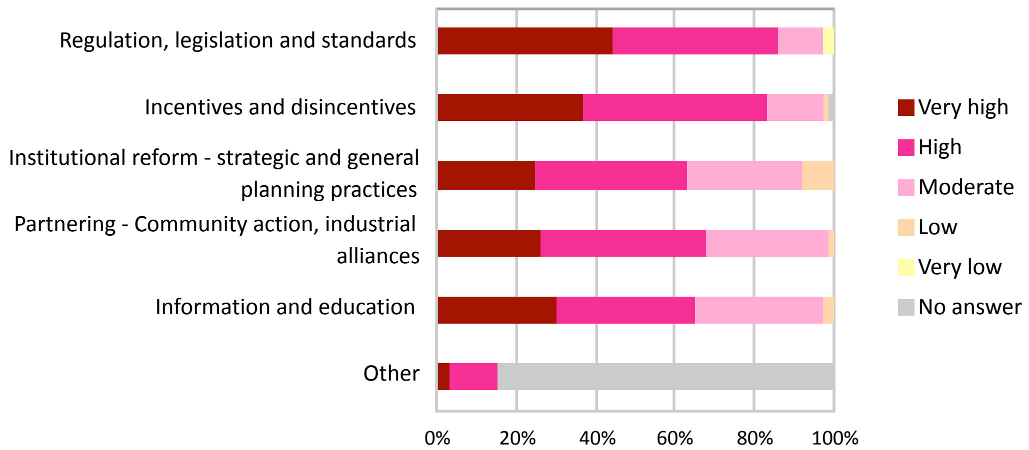


Fig. 27. Percentage of experts rating measures for achieving renewable energy autonomy.

Regulation, legislation and standards were rated the most significant methods for achieving energy autonomy, followed by incentives and disincentives. Institutional reform, including strategic and general practices was rated lowest overall. Other suggested measures related to political and administrative support, building capacity, target and strategy creation, infrastructure improvement, social engagement, and scientific research prioritisation. Further suggestions were behavioural in nature, such as setting good examples for other nations to follow or simply having the courage to decide new things.

Expert Comments to Question 5

Regulation, legislation and standards

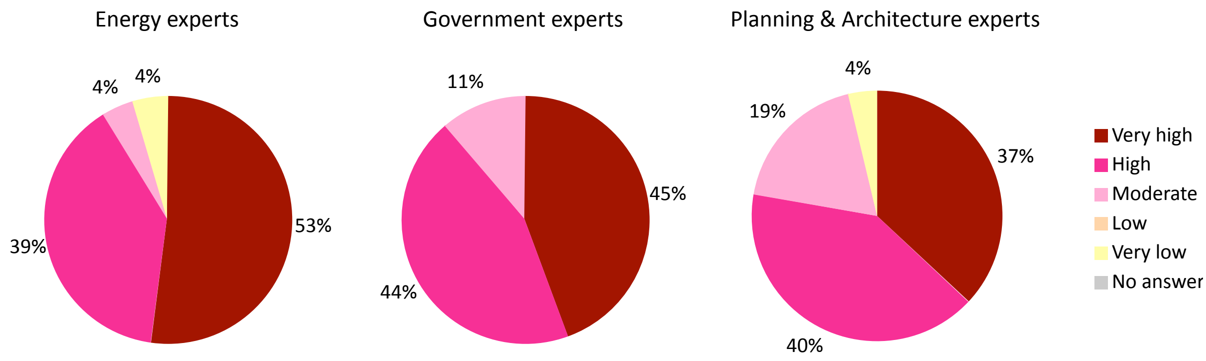


Fig. 28-29-30. Percentage of experts rating regulation, legislation and standards according to profession.

Energy and government experts were most likely to rate regulations, legislations and standards highly compared to experts in planning and architecture.

Based on the comments, regulation, legislation and standards were significant measures to create initial support (n=6), maintain efforts or ensure quality (n=4), and encourage competition (n=2). As part of a "push and pull strategy", they serve to initiate, motivate and help create the initial incentive for renewable energy efforts, particularly needed during the early stages. For one German planning expert, they "cause planning reliability and can be easily controlled". For another planner from the UK, they are "able to prompt the 'laggards' more quickly than having to rely on good exemplars and leaders". They can also maintain quality by "preventing "slippage" (back to old practices)", argued one US energy expert. "As command and control instruments, they have an important steering capacity", declared one Canadian government expert. And for one planning expert from Australia, they can create a "competitive environment and stimulate innovation" enabling renewable energy to compete with fossil fuels.

However, these tools do exhibit some limitations according to some experts. For one energy expert, regulatory approaches are fundamental but not necessarily sufficient. "They are high impact but they may only exist for the short time", argued one planning expert from Portugal. "They can help to improve the environment but only if related measures are also working for the energy changes", argued another planning expert from the US. They also depend much on how they are enforced or the strength of the drivers they contain, not to mention their appropriateness, declared several planners. According to one UK government expert, they need to be flexible enough to allow for a choice of measures as well as suit the scope of individual local governments. The latter argued some experts refers to the extent of their outreach (n=6).

Regulatory measures should moreover take broad effect. One US planning expert remarked, "no one group will undertake the full range of necessary adjustments without everyone being required to do it". This is pertinent to energy-use behaviours, which are highly influenced by societal norms. "Without normative instruments, the process will only reach few people and groups and hence progress is slow", argued another planner from Austria. One UK planning expert writes: "Take for example the current regulatory and legislative frameworks for energy supply and distribution. These frameworks favour large incumbents and often work against small, distributed solutions from multiple parties/ vendors. Hence regulatory changes are essential to level the playing field".

Indeed the ‘favouring’ of renewable energy over conventional energy in regulatory terms may not be the solution argued some respondents. According to one US energy expert, preference could result in an “unstable situation to justify new investments in renewable energy, especially since renewable energy has co-existed with conventional energy for a long time”. It is interesting to note that although regulations, legislation and standards can provide a level platform for all, their normalising effects can be seen as too conforming or distracting from other ‘more relevant’ issues (n=3). According to one energy expert from the US, what the community is interested in is not conformity but lowering their cost of living.

Any regulations established by local governments will also be highly influenced by centralised regulations and frameworks argued experts (n=4), especially since “local governments essentially work in a framework established by the state”, declared one US planner. The development of local codes for instance will still require national support; citing the Danish national policy as one example. However, for quick standardisation and widespread enforcement, centralised or even continental (EU) intervention may be necessary, according to one energy expert from Germany, because the development of regulations and standards at the local level may be fraught by inadequate or inconsistent information, expertise and frameworks.

Experts noted that the impact of standards is not necessarily guaranteed. For one planning expert from Switzerland: “standards always lag the state of the art because they are generated by lobbyists. Legislation is done by politicians who know mostly nothing about the technical matters of what they are legislating, and so depend on advise from consultants, whom are picked also for political reasons”. In due course, one Australian planning expert provides a tentative warning: “it is essential to establish certainty and clarity around what is needed and required - ever mindful of the disconnect between what is stated in statutory documents and what actually happens in a spatial sense”.

Notwithstanding the limitations, experts noted that regulation, legislation and standards can still actively pursue the governance of energy autonomy through buildings and renewable energy infrastructure development (n=8), technological innovation (n=3), energy distribution and supply guidance (n=3), feed-in tariffs promotion (n=2), and local government empowerment (n=2).

For several government experts, regulation, legislation and standards for new urban developments for example can help enforce energy efficiencies and increase the uptake of renewable energies. It can offer a framework for investment, for example, siting suitable locations for wind energy plants in local energy maps, guiding the installation of solar panels on roofs through solar cadastres, or directing the construction of carbon neutral housing via local planning and building codes. According to one Danish energy expert, local energy laws can also encourage and facilitate the meeting of producers, dealers and consumers to increase the supply of renewable energy. For example mobilising the participation of energy supply companies in community energy schemes as cited by one UK planning expert.

Appropriate local and national standards can encourage quick and widespread development of a new technology, whether it is in the building sector or in electronic consumer devices and vehicles procured by the local government or the wider community. The presence of the centralised feed-in tariff would furthermore boost technological innovation and affordability. For several German energy experts, the development of standards should however involve all levels of government and maintain close contact with the technology providers in order to quicken standardisation. The standards itself should exhibit a certain level of flexibility since stringent rules can also stall the development of a technology.

With regards to energy supply and distribution, legislative changes to level the playing field between centralised and distributed energy supplies is essential. One energy expert from Nigeria noted that local governments require “adequate legislation to enable them to participate in energy supply infrastructures that also enables governments to meet international standards in resource management and ensure the equitable and affordable supply of energy and its related services". When coupled with the gradual phasing out of fossil fuels, additional regulatory measures would also be required, asserted one government expert from Austria.

In relation to empowering municipalities through national legislation, there was a consensus amongst experts that this should essentially clarify the roles and responsibilities of local government to act in energy matters, and determine which energy regulation, legislation or standard apply where.

Incentives and disincentives

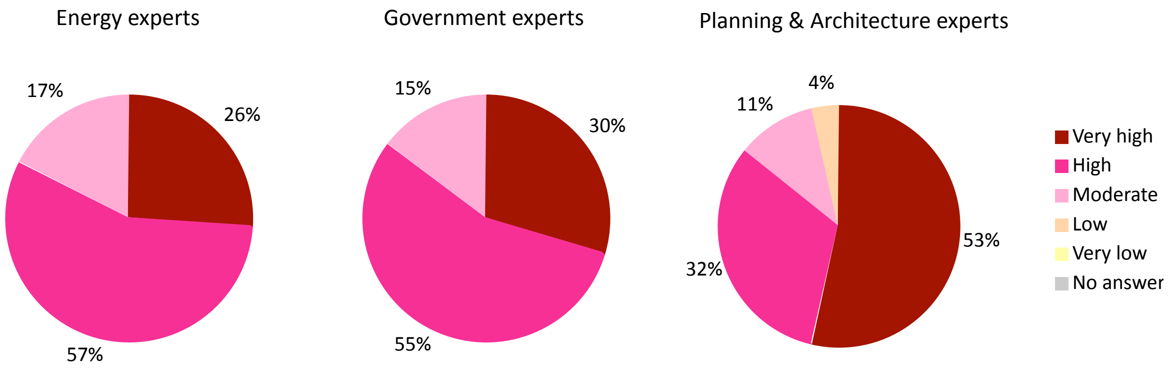


Fig. 31-32-33. Percentage of experts rating incentives and disincentives according to profession.

Experts from planning and architecture tended to rate incentives and disincentives more highly compared to energy and government experts.

Based on the experts' comments, incentives provide an effective mechanism to influence behaviour (n=12), to highlight the economic benefits (n=7), and to generally promote energy efficiency, renewable energy and other associated infrastructures (n=6). Without incentives argued one US planning expert, "the public will not respond", since incentives also provide signals to the community to "get on and do it". For one Japanese government expert, "they can enhance participation and reinforce actions". "They can stimulate the adoption of innovation and generate change", as well as" encourage high performance and discourage low performance", argued two planning experts from Australia. Furthermore, they are most useful when "transformative 'disruptive' infrastructure and processes may be needed", added the experts.

For most experts, the incentive most likely was the financial incentive. According to one Danish government expert, "people in general do not act on ulterior motives like saving the planet, but what they do respond to is the personal economic benefits gained". That is why economic incentives and disincentives are able "to cause rapid lifestyle and behaviour change", claimed one planning expert from India. It is the money saved money earned (or just breaking even) that is usually the key motivator. But for one planning expert from Australia, economic benefits are not necessarily a determinant, "particularly for richer households who use more energy and are not greatly concerned with costs so will probably not respond to incentives in the same way poorer households will".

In terms of the economic benefits that incentives can entail, experts tended to emphasise community or collective benefits rather than individual gain. One UK planning expert lists the benefits in terms of community ownership, community investment returns, or financial contributions to the community. According to one energy expert from Germany, "incentives should foster local decisions in favour of renewable energy legislation that lets local communities profit from tax revenues generated by local renewable energy generation and use". "They should encourage communities to adopt novel technologies and systems, employing incentives to also smooth over suspicions and other ‘teething’ problems”, argued on UK planning expert. Moreover, according to one Italian government expert, “they should support the local economy”.

Furthermore, economic incentives alongside public awards can help mobilise public and private investment (German planning expert), and incentivise “both the supplier and investor as well as the customer to participate in the rapid penetration of renewable energy technologies into the market (Nigerian energy expert). This is particularly crucial because “the cost of transitioning from an economy underpinned by fossil fuel to one underpinned by renewables will essentially be born by industry and business. They will be concerned with synthesizing one form of capital (raw materials) in order to create another (financial)”, declared one government expert from Australia. Thus, incentives for the business community to act in partnership with a newly empowered local government are also essential.

The type of financial incentives commonly mentioned by experts included grants, loans or rebates for energy saving actions and the uptake of renewable energy, tariff support, bonds or tax liens to lower upfront investment costs for renewable energy generation, and general investment in renewable energy technology innovation to bring it to scale. With regards to centralised feed-in tariffs, these according to one government expert from the World Business Council for Sustainable Development (WBCSD) will not work without appropriate *pricing* incentives.

Overall, there was very little discussion on *dis*incentives. One UK planning expert referred to them but in terms of removing those that “exist within the distribution (particularly 'the last mile') and the permitting and installation processes, for example, costs associated with linking to the electricity grid based upon distance”. The WBCSD expert noted the importance of removing disincentives that are found in contradictory policies, pricing structures and practices. For example, different taxes and pricing for different sources, including the use of water (the latter of which can have a huge impact on energy use). According to the expert, these disincentives can “run havoc with long-term forward-looking decisions that are required for sustainable energy action plans”. Two US experts noted the disadvantages of disincentives in that they can be counter-productive and “tend to produce political opposition” because “they involve ‘punishing’ participants for the lack-of-progress rather than informing and guiding them to action”.

Factors that may impact the effectiveness of incentives or disincentives relate to economic (n=5), administrative (n=5) and social (n=4) aspects. According to the experts, the success of incentives really depends on: financial resources, regulation and planning support. In the case of planning argued one government expert from Germany, “a very good integrated energy concept is essential”. Since incentives are somewhat reliant on the ‘free-market’, they may not be the most cost-effective or equitable mechanism in the longer term. In such cases argued one Australian planning expert, incentives need to be carefully evaluated, “the private sector should be allowed to determine the most cost-effective response”.

Incentives, according to one US government expert, may also expire. “They need to be implemented at the very least in the early planning stages”. They should ideally be credible and long-standing. Otherwise argued one US planning expert, “they will not be able to compete with existing sources of electricity in the short- and mid-term”. “Only with long and well known incentives from the government, will all parties know the economy of the investment in renewable energy and will be able to plan for this”, declared one Danish energy expert. Another important caveat is the assumption that everyone can be incentivised or disincentivised, which in principle is an impossible feat.

Institutional reform – strategic and general planning practices

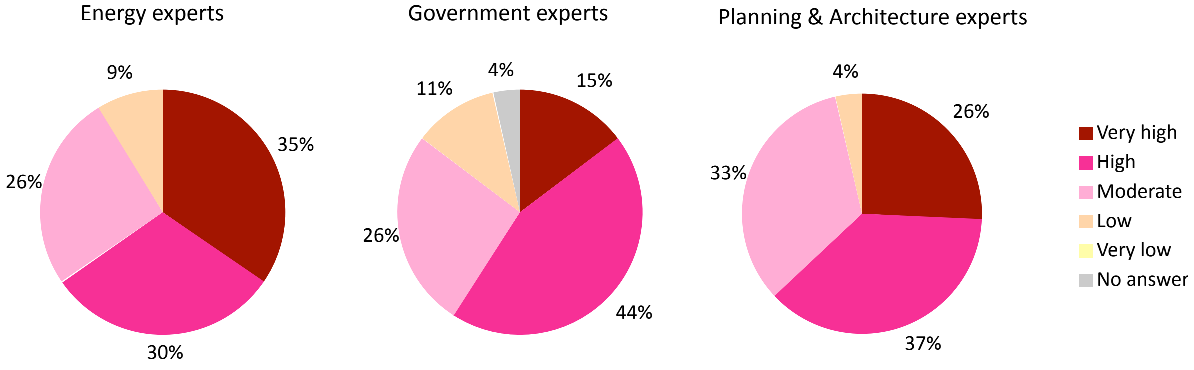


Fig. 34-35-36. Percentage of experts rating institutional reform according to profession.

Experts in government, and planning and architecture tended to rate institutional reform of strategic and planning practices low, while energy experts were generally most supportive.

The advantages to institutional reform according to the experts lie in its potential to create "a holistic change" (Australian energy expert), increase "organisational efficiency" (Swiss government expert) and achieve "a positive framework in the community" (German government expert). Most experts referred to revisions in planning instruments (n=18) and the enhancement of social networks (n=12) as their preferred modes of reform.

In response to planning instruments, US planning experts tended to focus on the creation of new planning *models*, which addressed property relations and energy efficient systems such as high-speed rail, or regional planning. Planning experts from Switzerland, UK and Australia tended to focus on strategic planning *design* or strategic planning *capacity*, whereby the former relates to technical, economic and social strategies to put new energy supply sources online, such as careful land use allocation and detailed planning of land use and urban energy networks, while the latter emphasised resource allocation in energy planning, with regards to the creation of new administrative or managing entities. This could be in the form of new departments in local government to link energy generation, energy efficiency, fiscal arrangements with building and planning codes, or, the creation of energy service companies and community energy companies to cooperatively manage local energy generation and supply. Implementation according to two planning experts from Germany and the UK could be enforced by strategic plans, in both design and capacity, that encourage renewable energy use in all planning fields and hence enabling private and public sector delivery of renewable energy. According to some German energy experts, revisions in legislation could also force current strategic and general planning practices to consider energy autonomy based on the mandatory use of renewable energy. Above all, consistency is essential. For several government experts from the UK, any changes should ultimately lead to a stable policy framework, encourage development that is systematic and provide constant feedback and information.

For many experts, institutional reform meant integrating stakeholder involvement and cooperation from the outset, and throughout the decision-making and implementation process. Actors would include local citizens, formal and informal institutions, energy market players, industries and businesses. But according to one US energy expert, "the *correct* identification and information of the salient local and regional partners" is essential. Through a "setting where collaborative problem-solving is encouraged", declared one US planning can the relevant actors reach a consensus on public policy and help shape overall public opinion. Conflicting agendas and disincentives can be addressed by “encouraging the rethink of contracts and responsibilities between the different parties”, stated one planner from Australia.

There were however some limitations noted by some experts to the institutional reform of strategic planning practices. One German energy expert argued that in the case of Denmark’s planning for heating, the mandatory use of renewable energy enforced through spatial planning was a major barrier because it often did account for local consensus. However another expert questioned where consensus is really needed. According to the government expert, “strategic planning is actually not about consensus building but about ‘hard choices’, not compromise”. In fact, he recommends that regional authorities should in particular be more empowered to act outright and to undertake strategic planning for sustainable urban development for the long-term.

To maintain the longevity of strategic planning can also be difficult. In the UK, it was noted by one planning expert that planning and regulations for solar or other renewable installations in unbuilt areas were complex, expensive, unpredictable, and can lead to higher costs and delays, often making local renewable generation uneconomic. Another energy expert from the UK argued that long-term strategies and planning have helped in the UK but only in a general way. Despite comparison studies of air pollution and urban energy modelling, their effectiveness in influencing action was actually more dependent on concrete short-term policy goals with enforced penalties. For one Danish energy expert, more critical is the national focus to develop and support renewable energy. For several government experts, reform will ultimately depend on the region, the country, the incumbent practices and in most instances according to one energy expert, the market place.

Partnering

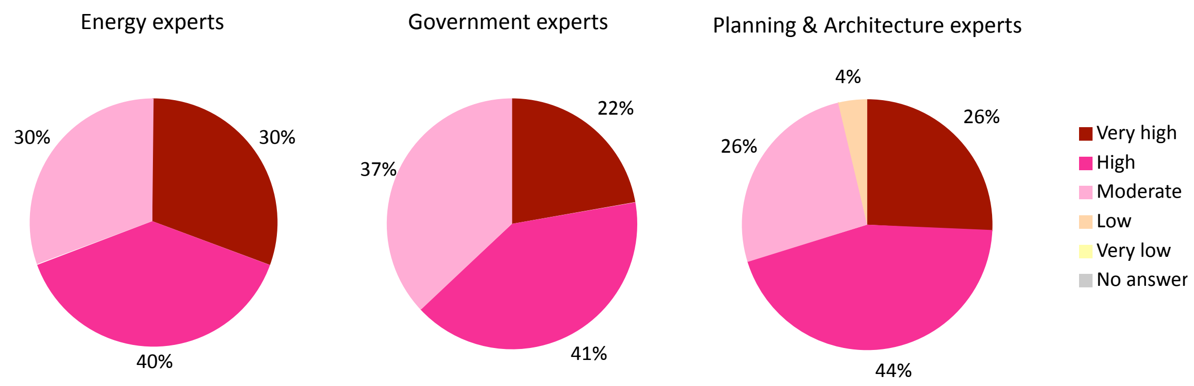


Fig. 37-38-39. Percentage of experts rating partnering according to profession.

Energy experts tended to be most supportive and positive of partnering. Experts from planning and architecture were most likely to be uncertain as to its ultimate importance.

Based on the experts’ comments, partnering was intrinsically a positive factor (n=29). Partnerships encourage innovation and experimentation, according to US experts in government and planning. “They can break new ground,” argued one German government expert, citing Freiburg in Germany and San Francisco in the US as examples. “They are a form of governance as opposed to just government”, declared one Australian planning expert, and “essential for a truly democratic response and outcome to the renewable energy challenge and opportunity in cities”. In addition, “partnerships can create enduring solutions”, remarked one energy expert. “They create acceptance, boost motivation, urging each party to perform, hence increasing the likelihood of success”, argued one planning expert from Austria.

Most experts referred to the public-private partnership or PPP (n=15) to pursue the goal of energy autonomy, highlighting the importance of industry alliances to link organizations, community and businesses. According to one US planning expert, these partnerships are "strongest at the local level, where much of the change needs to take place". They ensure community interest, ownership and action in order to deliver such a paradigm shift in the way people receive and use energy. "The public can have greater ownership of solutions, and schemes can provide benefits for local communities and individuals", argued one UK government expert. For another UK planning expert, industry alliances can "shift attitudes of established parties and make stakeholders out of potential adversaries with resources that can be brought into play". For experts from Germany, strong support from the private economy will however be critical, particularly the participation of the industrial sector, agricultural sector, energy suppliers, building companies, and local trades and craftspeople.

Industry alliances in particular can enable the mobilisation of funds and the effective management of energy projects. According to one Nigerian energy expert, "industry has the technical expertise as well as financial resources for establishing the energy project while the community needs the energy services. This interdependent partnering is therefore essential in attaining energy autonomy for sustainable socio-economic development of all stakeholders". In more practical terms argued one Australian planning expert, industrial alliances can more directly enhance the management of local generation and distribution, for example, using waste heat from a neighbouring company for combined heat and power.

For one government expert from Australia, "partnerships encourage innovation in order to overcome even the most regressive policy environment. It is a case of bottom-up, grass roots activism and politics enabling change, a far more sustainable form of change". Indeed, "partnerships are key where the local authorities do not actually control the energy system", argued one energy expert. "In energy autonomy, partnerships are especially obvious, given the distributed nature of generating renewable energy", asserted one Australian government expert.

However, some respondents noted limitations to their implementation and effectiveness (n=17). For some planning experts, partnerships need to be 'designed', requiring some *transitional* arrangements (Australian expert) and a new *culture* of cooperation that considers the needs and benefits of all (Austrian expert). Consequently, these may add to the organisational burden to getting things done (US energy expert). Processes to set up afresh each time on an individual community basis may become time- and resource-consuming (UK planning expert), causing a rise in transaction costs due to exchanges of information and agreements (Canadian government expert). Furthermore, successful partnerships will depend on key individuals, their motivation (UK energy expert) and the 'professionalisation' of communities (UK planning expert). In relation to private sector involvement, this will also requires some constraints, such as on energy services companies to ensure consumer protection (UK planning expert). Meanwhile, the cost-effectiveness of partnerships, according to one Swiss government expert, must be combined with incentives to ensure improvements are lasting. And goal inconsistencies between the private and public sector be considered since these will have an impact on project initiation. Indeed, while industry may want to help, they may not be traditionally (or commercially) aligned with the vision of energy autonomy (US government expert).

Information and education

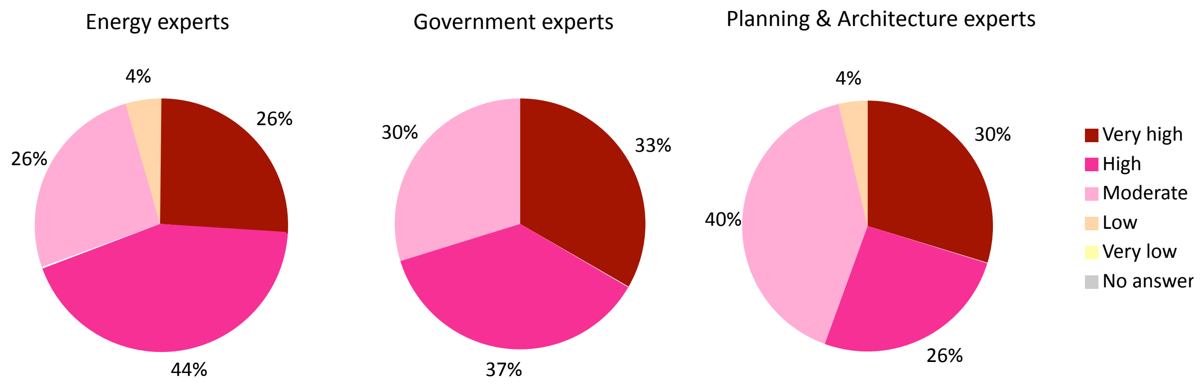


Fig. 40-41-42. Percentage of experts rating information and education according to profession.

Government experts tended to rate information and education most positively compared to other experts. Planning and architecture experts tended to be most sceptical.

Based on the comments, information and education in energy autonomy are essentially long-term measures (US energy expert), which can generate support for renewable energy efforts (US government expert), and aid the development of community capability to deliver renewable energy (UK planning expert). “People must understand what they are supporting, where they are going as a community and why”, argued one Australian planning expert. For one Swiss planning expert, they are “the key to a democratic system making informed decisions”. For one UK government expert, providing advice, information and education will also “overcome inertia to action due to uncertainty”. By not acting as “show-stoppers” like regulations, incentives and partnerships, their presence also helps “maintain continuous advocacy’, argued one energy expert from the UK.

However, experts highlighted several drawbacks to information and education (n=16). For one Australian planning expert, the problem did not concern the *provision* of information, but the determination of “the right kind of information and education”, as well as to whom it is targeted to. “Besides financial feedback, correct information on energy efficiency and renewable energy, as well as stakeholder information are critical”, argued one German energy expert. Planning experts from the UK and Portugal noted that for many, the issue has not been where the energy comes from or its carbon content, but knowing that the energy supply is reliable and affordable. Consequently, “payback periods and tax incentives are most important to them” and indeed ways “to help navigate the legal and financial hurdles of delivering and maintaining local renewable energy sources”. “Cost-“effective solutions are essential, compared to just caring about the problem”, argued one US energy expert. Furthermore, information and education “needs to be targeted to the right people as 99% of the population are not involved in the development, construction or operation of renewable energy projects”, argued the UK and Portuguese planners.

According to another planner from Australia, education is not necessarily enough to change energy behaviour. Information should also be accompanied by regulatory and incentivising measures. In Boulder, United States, despite the focus on education as part of their climate action plan, change was negligible until regulations and added incentives were added to change behaviours and improve building efficiency, reported one US government expert. Indeed, the availability of information also does not necessarily push people to act, as reiterated by two German experts in government and energy. Existing prejudices and traditional thinking are factors. One Australian government expert writes:

> "In Australia, the search for truth has meant slow progress as people strive for an absolute position. In countries where the media prioritizes critical perspectives over popular ones, progress is not based on absolutes (how can it be) but on best evidence. This results in a more fearless and therefore more progressive society generally".

Indeed time is the essence. For a few planning experts from the US, information essentially needs to be provided on a timely basis and should moreover, start early. However, because these methods usually entail considerable periods to take effect, they can also be unreliable, argued one planning expert from the UK.

As to which measure was more effective, government and energy experts tended to focus on education rather than information. (It is important to note that education was universally supported as being necessary, particularly for the young. However, for one German government expert, a transparent communication process on the local level would be more appropriate for adults.) According to one government expert from Denmark, "businesses and craftspeople will need sufficient levels of competence to provide the new technologies required". "Investment is essential in education programs such as new courses and degrees related to renewable energy", argued one German energy expert. "Human and institutional capacity building is necessary to sustain the scientific, engineering, technical and management skills relevant for the design, development, fabrication, installation and maintenance of renewable energy technologies", wrote another energy expert from Nigeria. Essentially what is required is a new type of technical culture, argued one architect and urban planner from Italy. Training via close cooperation between industries, universities, professional firms and local governments, will help develop a whole repertoire of energy efficient techniques, technologies and tools. For one government expert from the UK, local government plays an important role in educating through the implementation of demonstration facilities, one-stop energy shops or agencies, and local energy events or seminars.

3.3.6 Question 6: How do you rate the organisational options in energy autonomy?

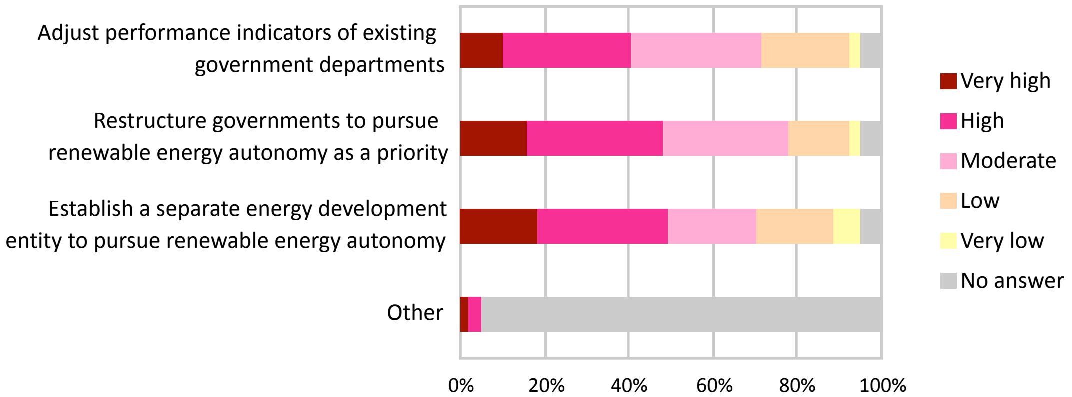


Fig. 43. Percentage of experts rating organisational measures.

Interestingly, establishing a separate energy development entity was rated higher than restructuring government or adjusting indicators of existing local government departments. Even so, restructuring tended to elicit more positive responses compared to the other given factors. Other measures suggested by experts included developing adequate manpower for renewable energy autonomy, and participating in competitions or awards. Additional non-organisation related suggestions included tariff reform, assessment of individual fossil-carbon footprints, and ongoing monitoring and evaluation of progress towards renewable energy targets.

Expert Comments to Question 6

Adjust performance indicators of existing government departments

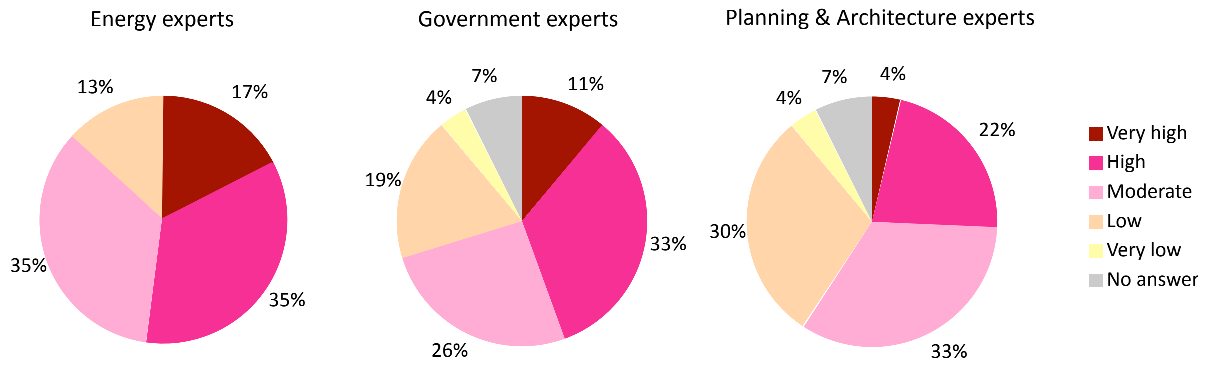


Fig. 44-45-46. Percentage of experts rating the adjustment of performance indicators according to profession.

The adjustment of performance indicators of existing government departments tended to elicit positive responses from energy experts. Interestingly, experts from planning and architecture were less supportive compared to government experts, who were initially assumed to be more likely against any measures that required adjustments to existing frameworks.

Several experts noted key advantages to integrating energy indicators into existing performance indicators (n=7). For one government expert from the UK, this approach could raise the profile of energy and lead to the increased allocation of resources and the alignment of efforts to support this area. To achieve energy autonomy in particular, local governments can specify "performance in terms of deploying renewable energy autonomy for both public departments, ministries and agencies as well as for private homes and businesses", argued one government expert from Nigeria. For two energy experts from the US and New Zealand, such integrated indicators will also allow departments to demonstrate their leadership.

Despite the advantages, limitations to such tools were more frequently discussed (n=28). Conceptually, indicators "can only serve as reference", argued one Japanese government expert. As a tool of new public sector management they are useful but they "more often speak to bureaucratic processes than transformative change", argued one planning expert from Australia. As a result, indicators may mean additional work due to the need for continuous review. According to one planning expert from Switzerland: "performance indicators require too much non-productive time spent trying to look good". Adjusting existing government indicators may also be very difficult, argued two planners from the US and Italy because local administration will take this as a slowing down of existing processes and practices. Often tools such as these frighten the authorities due to the complexity of information and method that underlie them. Consequently, one Italian government expert maintains that if they are to be useful, one will need to "give the impression that no complicated activities will arise". Furthermore, the ability of indicators to easily measure progress will need to be emphasised. For one Austrian planning expert, indicators should really focus on specific aspects such as calculating the rate of dependence on fossil and nuclear resources, and measuring CO_2 emissions from the different urban sectors.

The indicator approach is especially futile if there were no performance indicators in place in the first instance, let alone those for energy. One German planning expert noted that local government departments might not even be guided by indicators in the first place. Even if indicators were present contended another US expert in planning, they "may not even be followed", while some "may be bypassed”, argued another planner from Germany. “Local governments are reactive, compliance-based organisations in the main - ways will be found to minimally comply with targets or indicators”, argued one energy expert from China.

There were queries as to whether energy indicators should even influence administrative performance or project performance. According to one US energy expert, the former is easier since government can control only a limited number of facilities within the community. However, for other experts, adjustments to local government performance are inevitable. For one energy expert from Nigeria:

> “The performance indicators of existing government departments have to be assessed and evaluated to know how well they are doing based on their work schedules and to also know if such performance indicators will be adequate for the renewable energy project, and to know which of the existing department will be able to take up the additional responsibility of renewable energy project to attain renewable energy autonomy or the need to establish a new department for the renewable energy project. Based on these, the performance indicators may have to be adjusted”.

The effectiveness of administrative performance also depends on the given responsibility and scope of work by local government. Indicators, according to one government expert from the United Nations, are “not typically the work of local government but a private sector approach”. Furthermore, because “most of them [local governments] are not even familiar with the challenges and the solutions concerning renewable energies”, this affects how performance, in relation to work on energy, is ultimately measured, evaluated and reported, argued planning experts from the UK and Austria. Two Australian government experts cited the example of local governments in Australia where:

> “…performance has been measured in terms of outputs rather than outcomes. This is because they are organised having regard to professional specialties rather than outcomes. Increasing renewable energy from many sources is an outcome not the production of an output. Therefore outcomes should be measured”. … Furthermore, “performance indicators typically measure corporate performance in and of itself. They often extend to measuring outputs only and by virtue of quite crude criteria. They are by and large, a hangover of a 'service' mentality. New techniques are slowly being considered but until the 'business' of local government is reformed, these attempts are largely futile.”

Another possible drawback to integrated energy indicators by local government is the possible competition created between the different departments, in that, although competition can act to motivate individual departments to achieve high performance, this can have negative effects in discriminating them, instead of encouraging the intensive cooperation necessary to achieve energy autonomy, argued one German energy expert.

Restructure governments to pursue renewable energy autonomy as a priority

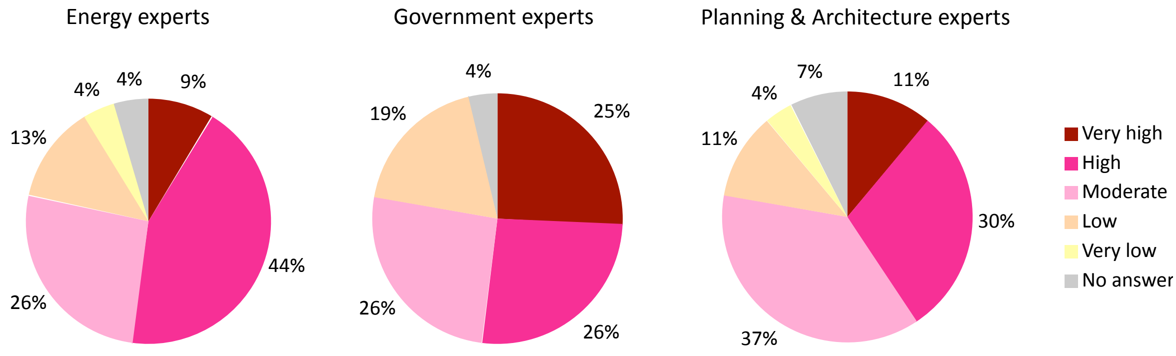


Fig. 47-48-49. Percentage of experts rating restructuring according to profession.

Interestingly, government experts tended to rate restructuring higher than experts in energy, or planning and architecture.

Based on experts' comments, adjusting local government structure can be advantageous (n=20). Restructuring can "demonstrate political will", declared one expert from Australia. "The more focus and the more people dedicated to renewable energy, the more results will follow", argued one Danish energy expert. According to two US energy experts, local governments can restructure to allow them to become test beds for locally viable solutions, and therefore influence community perception of the local government's intentions.

Several government experts emphasised the importance of restructuring in order to shape opinions. Indeed, restructuring signals "an important paradigm shift" (US government expert) or forces "a rethink by government" (Japanese government expert). "Under the contexts of serial and worsening environmental and economic crises" restructuring argued another government expert from Nigeria, is inevitable. In the light of energy autonomy as a new type of economic activity for local government, one Australian expert, the phrase "new business, new structure" becomes pertinent.

However, planning experts from the German-speaking countries recognised that to restructure the energy system to achieve energy autonomy would require changes that "retain their force" over a long period. Energy autonomy would need to be "set as a priority against all other government functions", argued one Australian planning expert. Appropriate structures will be needed to support new forms of financing arrangements required to pursue energy autonomy. Local governments would require a framework in place that allows investments to come principally from the private sector, argued one government expert from the United Nations.

Several experts warned that restructuring does not guarantee success in implementation. For one energy expert from Germany: "such a restructuring can be effective, provided that the necessary means (decision power and financial resources) are also made available. An example of a country with its own ministry for renewable energies is India. However, the progress of renewable energy use in India was rather moderate despite the official priority pronounced by the creation of that ministry". This expert did not offer an explanation for this failure but according to one Indian planning expert, it may have been due to restructuring being centralised, which subsequently meant limited support for regional policies. Like most methods, restructuring is highly context-dependent. It may be absolutely necessary in some countries but not in others, argued one UK energy expert.

Experts also queried as to the *necessity* of local government restructuring (n=10). According to one US planning expert, restructuring is yet another slow process that must be undertaken in concert with many other steps, especially education and public support. What is more important is to ascertain the effectiveness of the existing governmental structure to pursue energy autonomy. According to one Austrian planning expert, "it makes no sense [to] have a new entity [if] the old institutions work. The old one will fight against the new one". Furthermore, one Australian expert argue there is no evidence of the connection between governance structure and performance. Often, it is really just a matter of political leadership. One energy expert from New Zealand cited the towns of Växjö in Sweden and Güssing in Austria as examples where the presence of a champion displaced the need for restructuring.

There were also queries as to whether energy autonomy should even be the responsibility of local government. For one UK planning expert, it did not make sense if "renewable energy autonomy is not even treated seriously by the existing government", or according to one Chinese energy expert not seen as a "core function of local government". For one energy expert from the UK, the vision is actually a matter for central government because it affects "national security and the economy".

Experts argued that priority setting should really be the main concern rather than restructuring (n=10). According to one Australian planning expert: "renewable energy must be seen and understood as a priority for systemic change to energy systems in cities". "If renewable energy autonomy should be a political requirement it would be important to declare such a strategy as a priority", argued one government expert from Liechtenstein. For experts in the UK, this means re-aligning activities to be more supportive of renewable energy. For example, adjusting indicators to change the *order* of priorities, suggested one government expert from the World Business Council for Sustainable Development, or creating regulations such as the Merton Rule in London, where a new local priority has had a big effect on installation of renewable energy, noted one energy expert from the UK. At the same time, it is important that governments are made aware of the opportunities and remove programmes and institutional frameworks that inhibit renewable deployment as a first priority, an aspect which does not require a restructuring, argued one UK planning expert.

Others noted that it might be more a matter of ascertaining the demand for energy autonomy by certain sections of society (n=3). According to one planning expert from Switzerland, the problem is essentially "the lack of demand by the public to put renewable energy in place". For one German energy expert, "it is not the structure [but] the heads and the hearts of the bureaucrats". For another, "it is the local utility, which must undertake the local activities (at best owned by the people)", not the local government taking the driver seat.

Establish a separate energy development entity to pursue renewable energy autonomy

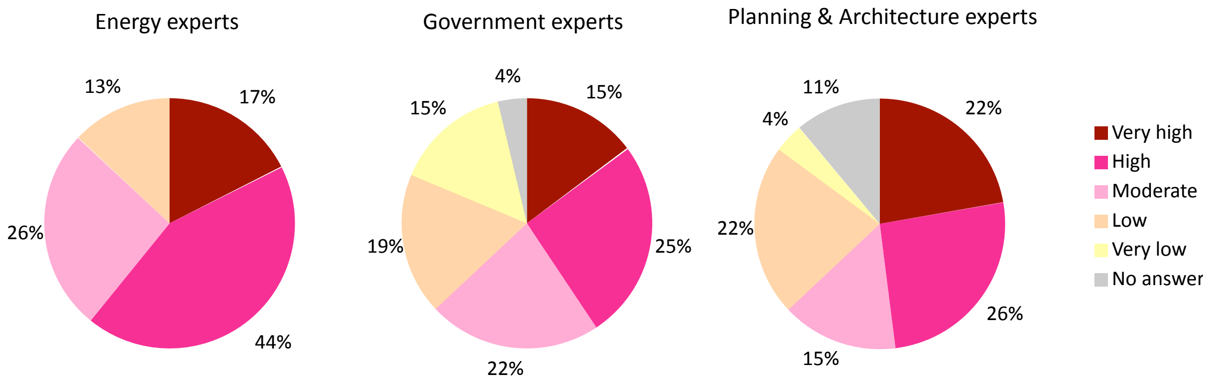


Fig. 50-51-52. Percentage of experts rating the establishment of a separate energy entity according to profession.

Energy experts were more likely to rate a separate entity highly compared to government, or planning and architecture experts.

The idea of creating a separate entity to pursue energy autonomy received several positive comments (n=12). For two energy experts from Germany, installing an entity that is responsible for energy aspects and that is involved in all relevant planning and governmental processes, is necessary to make energy an important aspect of integrated planning. They insist that there are already several examples of separate energy development entities set up to foster sustainable energy development. For example, the Upper Austrian Energy Saving Association is an association, which has achieved a long period of continuous and successful activity, backed by the continuous support of the regional government of Upper Austria. Other examples cited by experts included the 'Community Energy Scotland', an organization, which was endowed by the Scottish government with the purpose and remit on energy policies (cited by one UK planning expert), and the Swiss Federal Office for the Environment (SFOE), which pursues energy development through the advancement of renewable energy and energy efficiency (cited by one Swiss government expert) by municipalities. It is important to note however that these are non-local entities.

At the local level, experts have highlighted the success of municipal utilities, energy service companies (ESCOs) and community energy cooperatives to oversee energy localization efforts. In the UK, the mantra “power for and by the people” has led to the development of ESCOs and Provident Societies. In Austria, the municipal utility in Güssing has been instrumental to its success in becoming energy autonomous. According to one UK government expert, “local energy agencies can help facilitate renewable energy autonomy on behalf of the local authority. This could be part of a local authority or a separate entity. There is also the possibility for activities to be undertaken by the local authority itself”. The success of community energy cooperatives was highlighted by one German energy expert, who cited the examples of the island of Samsø in Denmark, and the city of Shonau in Germany. In Samsø, local citizens were able to participate in the ownership of the most important local renewable energy plants. In Shonau, 624 citizens were able to own their own decentralized renewable energy power plant by repurchasing the municipal utility from the regional energy company. And even if energy autonomy was not a stipulated goal, independent entities did show several advantages over governmental institutions. They were able “to drive energy, innovation and pilot new projects” (Australian planning expert), “involve a broader range of players from society and act more flexibly” (German planning expert), and ultimately lend to “enhanced accountability” (German planning expert).

However separate entities require sufficient capacity. According to two energy experts from Denmark and Germany, more people dedicated to renewable energy are required to pursue energy autonomy. The type of persons and their position in government is critical, argued one Austrian government expert. Meanwhile any new entities created should possess “a singular focus and be directly linked to the highest level of government such as the mayor’s office”, asserted one planning expert from Australia. If this does not occur, there will be “resistance from the status quo,” argued one US planning expert, “there will be those who will actively work to diminish its power”. For one UK planning expert, capacity will also mean “the ability to access finance, pursue private-sector partnerships, to ensure capital is deployed in service of local energy supply - rather than in a strategic or governing body only”. Consistency and longevity of financial support schemes to maintain the entities are key. “The only way it would have a chance of success is to fund it adequately for significant period of time, ideally from private funds or a low per-person surcharge”, argued one US planning expert.

However, a few experts remarked that a new entity does not automatically ensure *better* implementation. Indeed, many experts were sceptical of such independence and separation (n=19). For one government expert from Japan, “separation and new entity means marginalization (not main streaming)”. “Such an entity becomes its own lobby and pressure group and is seen as having 'vested' interest in renewable energy”, argued one planning expert from India. Any resistance must be addressed since energy autonomy requires “a whole of government approach”, remarked one energy expert from Australia. And although ‘offshoots’ may be a good solution in some places like Samsø in Denmark, it is not an absolute requirement. Like most approaches, it is still context dependent, and impacted by local market conditions or government purpose and remit, argued one energy expert.

Several government experts also warned the creation of “yet another silo” (n=3) since a separate agency was seen as “yet another sectoral approach”. This is similarly addressed by one expert from Australia who wrote: “An agency like this runs the risk of consigning yet another strategic issue to becoming at best, the focus of pleasant advocacy or at worse, the political capital of a silo-like agency that operates like a bull in a china shop”. And if one speaks of energy autonomy: “renewable energy itself should not be too divorced from overall energy initiatives”, argued one US energy expert. “Synergies in energy efficiency, energy storage and variable renewable production will be even more significant as we move to higher penetrations of renewables”.

Consequently, government and planning experts preferred that the work to pursue energy autonomy was incorporated into existing entities, rather than employing resources to establish extra bodies (n=13). Energy units within existing departments are sufficient, argued one government expert from the United Nations. For one Australian planning expert, it is important that renewable energy is “integrated with current or modified mainstream systems, not stand alone”. “We need to mainstream renewable energy and energy efficiency into existing government structure. This will ensure a gradual transformation to a renewable energy society” argued one government expert. For three planning experts from the UK, US and Australia, this approach would better “raise the profile of energy across existing government departments” and “allow energy to be integrated into all aspects of sustainable development” as well as across other urban sectors. “Other government entities must also be involved and committed, for example, industry, transport, education, environment”, added one UK energy expert. Overall, integration is a more effective approach because it enables all parties to share a common responsibility and participation in the success, argued one Italian government expert. A whole new department or division is especially unimportant if the existing organization is restructured based on outcomes (in energy efficiency and renewable energy), declared one government expert from Australia.

However, working with existing structures can be complex because it requires that existing departments are flexible enough to adapt, otherwise conceded one planning expert from Switzerland, a new department may be the only solution. Although there is merit to either approach: independent or integrated, due diligence is always required in the first instance. This was summed up by two experts from Germany:

> "It is necessary to analyse the local structure first [because] maybe existing actors are able to fulfil this function"…"At first we should utilize what we have. A new entity will not necessarily make things better. They might even increase bureaucracy. Only after using established possibilities could a new entity be founded based on experience available after time and projects evaluated".

Furthermore, other supporting measures should also accompany either approach. According to several US experts, there should be a simultaneous focus on education and promotion (energy expert), on the derivation of a total energy plan (government expert), the improvement of costs and performance, as well as the presence of incentives and disincentives (planning expert).

3.3.7 First round summary

The use of the term energy autonomy needed clarification in the context of local government decision-making and implementation. For some experts, the concept of energy autonomy was overly ambitious, unrealistic or too abstract. The geographical limits of energy autonomy were also unclear. Several experts suggested that it would have been best to focus on specific actions, targets or outcomes in energy efficiency and renewable energy rather than dwelling on abstract discussions on energy autonomy.

Local energy capacity models were regarded primarily as *conceptual* assumptions. Based on comments, they needed to be adaptable, extendable, transparent, understandable and accessible to be of most use to local government. They need to be developed with the participation of the municipality to better respond to local conditions. When applying energy models, scenario development and the visualisation of community benefits needed to be prioritised. However, the work entailed in maintaining such complex energy models must be considered in the context of local government capabilities.

According to the experts, regulations, legislation and standards should be used to prompt those who are trailing in implementation while prevent those ahead from slipping back to old practices. These tools should also take broad effect in order to level the playing field, especially between centralised and distributed energy supply utilities. National regulations can assist in empowering local governments with the political, technical and financial capacity to pursue actions in energy autonomy. This will help them to address existing priorities and practices that may be in conflict with the pursuit of the vision.

Incentives, rather than disincentives, were considered best to stimulate innovation particularly by private enterprise, which for most experts will bear the overall responsibility for the long-term implementation of energy autonomy. Although incentives were argued to be susceptible to the free market, they could at least provide ample economic benefits for the community in the short-term.

According to the experts, institutional reform best serve to signal change and organisational efficiency. Based on comments, reform could refer either to the design or redesign of government concepts and strategies, or refer to structural adjustments in political capacities, that is, in defining new roles and responsibilities to drive energy autonomy. Overall, drastic changes to existing organizational arrangements of municipalities were not considered necessary to achieve energy autonomy. Instead, the experts regarded mayoral leadership, cross-sector coordination, and the presence of an energy commission to operationalise energy projects, as the required changes. However, there was a concession that the establishment of a separate energy development entity outside the established structure may be essential if the existing framework was found to be incapable of carrying out the necessary functions to pursue the vision.

Changes in existing urban planning practices to pursue energy autonomy were not considered significant for most experts, although reform in the context of setting energy autonomy as a municipal strategy was deemed essential.

Still, some experts noted that there was great potential to rethink urban planning philosophies for pursuing energy autonomy, since these can at the very least, help increase awareness of the energetic possibilities. Local governments can revise existing planning methods or create new measures with regards to local energy potentials modelling, building and planning certification, facilities management, and citizen participation.

Partnering for the pursuit energy autonomy was also considered important to break new ground and achieve a paradigm shift in the wider community, particularly amongst businesses and industry. The identification of the correct and relevant partners is therefore paramount. Partnerships can help local government evolve their traditional role from being mere service provider in “roads, rates and rubbish” to one that is also engaged in the “business of energy”, collectively guiding the local energy supply network on the basis of a clear energy autonomy strategy. By placing operational energy indicators within government that can help gauge the energy performance of individual departments, this business paradigm can be followed through.

The active education of all parties was deemed critical to the long-term pursuit of energy autonomy, more so than the passive provision of information. The right kind of information was as important as the determination of the best method of delivery. Critical was to understand from the outset the local government’s level of knowledge on energy matters since this would significantly influence initial motivation, the quality of energy concepts developed, and energy projects chosen to implement.

Education, partnering and reforming planning practices would therefore be necessary to affect change in the long-term, compared to regulations and incentives, which would have direct impact but may be short-lived.

Overall, the results of the first round showed that there were various viewpoints with regards to local government action to pursue energy autonomy. Comments differed in terms of the impact the vision would have on local government practice as incumbent fossil-nuclear energy systems are replaced with RES. These effects relate to how local governments will deal with the knowledge of energy potentials, how they will cope with developing their own energy systems based on RES, how they will lead and organise themselves to exploit the different RES, how they will seek and establish partnerships, how they will adjust existing urban planning practices, and how central and regional governments can support their endeavours to achieve energy autonomy.

3.4 Second round results

3.4.1 Distribution of responses

Like the first round, the second round also involved experts from urban planning, architecture, energy and government. Only experts who took part in the first round were invited because the second survey intended to review the extent of changes in opinion towards energy autonomy and ability to gain consensus on certain local government tools and organisational measures. The second round consisted of 3 multiple-choice and open-ended questions. The first focused on the definition of energy autonomy and the opportunity to change first round responses. The second focused on legal and financial measures. The third focused on staff, budget and organisational measures. The last two questions related to the need expressed in the first round to focus on specific actions, targets or outcomes that would ‘translate’ the meaning of energy autonomy. They refer to the territorial processes and administrative actions, and the two aspects rated most significant: the development of regulations, legislations and standards, and the creation of an urban development entity to pursue energy autonomy. The second round did not further examine local energy potentials models, energy awareness, or empowerment, as expressed in the first round, but are pursued in Chapters 4, 5 and 6.

The survey was sent to the 77 experts who participated in the first round, as an on-line and PDF survey. The survey response rate was 31% with 24 experts responding. Most experts came from Germany (29%) and the United Kingdom (17%) and were mostly from the fields of government, planning or architecture.

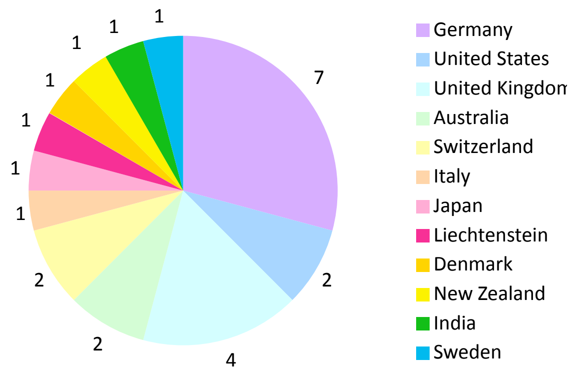


Fig. 53. Number of experts by country.

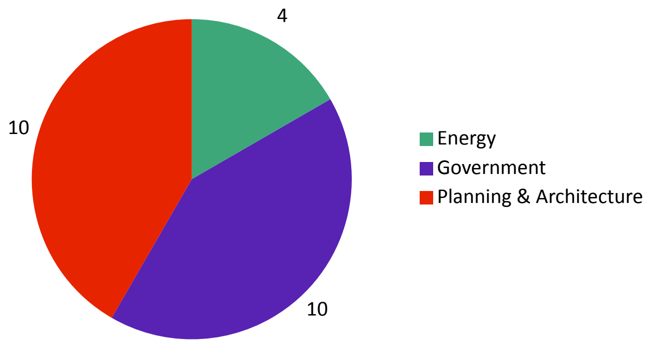


Fig. 54. Number of experts by profession.

3.4.2 Question 1: Would you change/add to your opinion of energy autonomy from the first round?

The first round of the Delphi Survey revealed a wide range of views in relation to the term '*energy autonomy*. In the second round the term was clarified as follows:

> In the context of this study, energy autonomy describes a special planning attitude, not a numerical condition; that is, it is not about the mere application of efficiency measures and renewable energy systems to the conventional energy, planning and development regime of a community or nation – but about the focused and methodical pursuit of complete local and regional independence from all non-renewable energy sources. This may involve strictly local measures, but also engage or rely on regional, sate or national support frameworks.

Based on this definition and results of the first round, would you a) change or b) add to any of your earlier comments made in the first round?

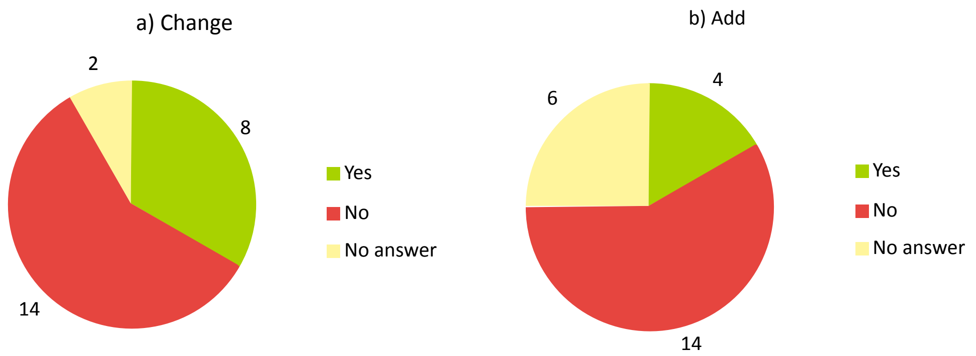


Fig. 55-56. Number of experts who opted to change or add to earlier comments from the first round.

Expert Comments to Question 1

Experts largely maintained their previous understanding of energy autonomy from the first round, even by those who expressed scepticism from the outset. For experts from Germany, the term *energy autonomy* remained problematic because according to them, it first did not sufficiently account for the differences in size and geography between villages, towns and cities; second, it implied that non-renewable sources of energy such as coal, oil and nuclear can be taken into account; and third, it implied that energy efficiency may not be included. Meanwhile, *local energy autonomy* was criticised by one German government expert because:

> "It implies that at the local level, renewable energy autonomy is possible. This depends today and I'm sure within the next ten years on the local conditions. Berlin without the surrounding state of Brandenburg won't be renewable energy autonomous, while the town of Sondershausen in Thüringen could".

According to one German energy expert, *energy autonomy* might also not be taken to mean RES:

> "It might be a solution based on oil (e.g. for Middle East states), coal (e.g. Australia) or nuclear (e.g. France). Furthermore, it might include solutions based on renewable energy, [but those] which are not the most efficient ones (for example, private houses cut off from the grid with small photovoltaic installations and a battery, instead of smart plus-energy houses)".

For this expert, *renewable energy-based* or *sustainable energy* was preferred. In conceptual terms, one German expert in planning and architecture argued that the real goal should rather be on *local and regional independence*, and not a 100 % goal, as this would give energy efficiency greater attention in its integration into the wider framework.

One government expert from Australia was still uncertain as to whether the changes required to become 'autonomous' was really a political or technical exercise:

> ”It is important that statements such as these reveal the process required to enable the change needed. It is no longer useful or relevant to create technical visions of the future (and therefore prioritise disciplinary knowledge). Instead we need to privilege the political process of creating these visions of change and the actions required to deliver".

The confusion as to what constitutes energy autonomy was reflected in the comment of one planning expert from the UK who even queried: “why energy autonomy as such should only include renewables".

On the other hand, most experts were in agreement with the proposed definition provided by the author. According to one UK planning expert,

> “This definition makes a lot of sense, as it brings attention to the institutional relations and political conditions that regulate energy flows, rather than a narrowly understood spatial definition. In other words, energy autonomy can be understood topologically, as a territorial phenomenon, rather than topographically”.

While for those who supported the concept of energy autonomy (mainly planning experts), there was a certain implicit understanding for the need to coordinate political, physical and natural resources to pursue this goal. The benefits in an improved urban quality from utilising available energy tools to pursue energy autonomy for example was highlighted by one Italian architect and urban planner who writes:

> “Energy models would be perfect instruments… to extrapolate the specific well tempered contextual build environment, in order to reformulate an appropriate new renewable energy autonomous planning and building design… We can define size, form, technology, and local mix of renewable energy sources in a rational network of energy districts, intelligent smart grids and building efficiency…. The renewable energy autonomous target, besides the reduction of greenhouse gas emissions and the optimization of the overall energy saving, will help us obtain a new urban quality and positive economic value”.

3.4.3 Question 2: How do you rate the recommended financial and legal measures for energy autonomy?

Financial measures

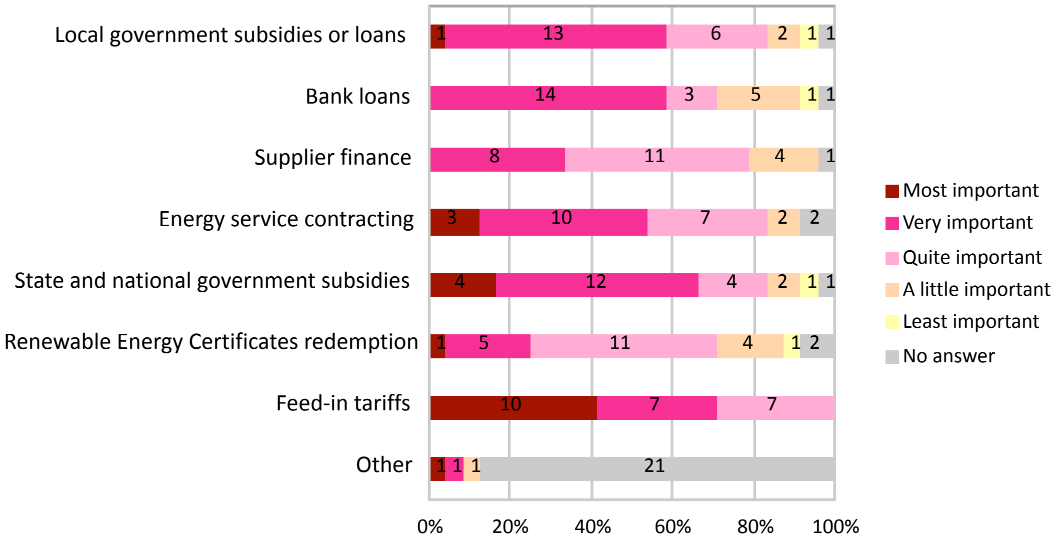
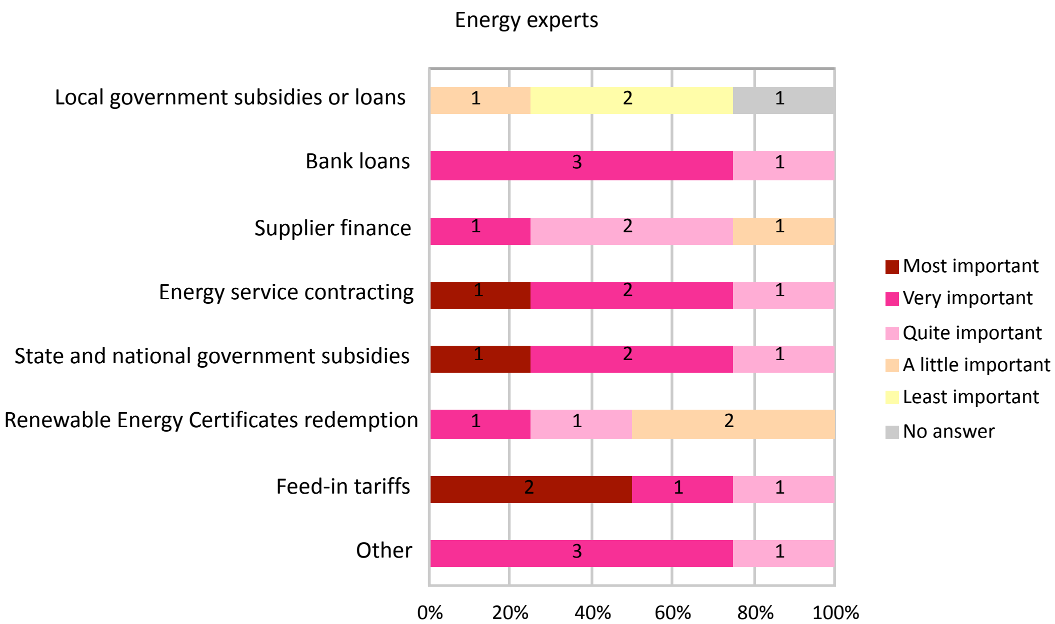
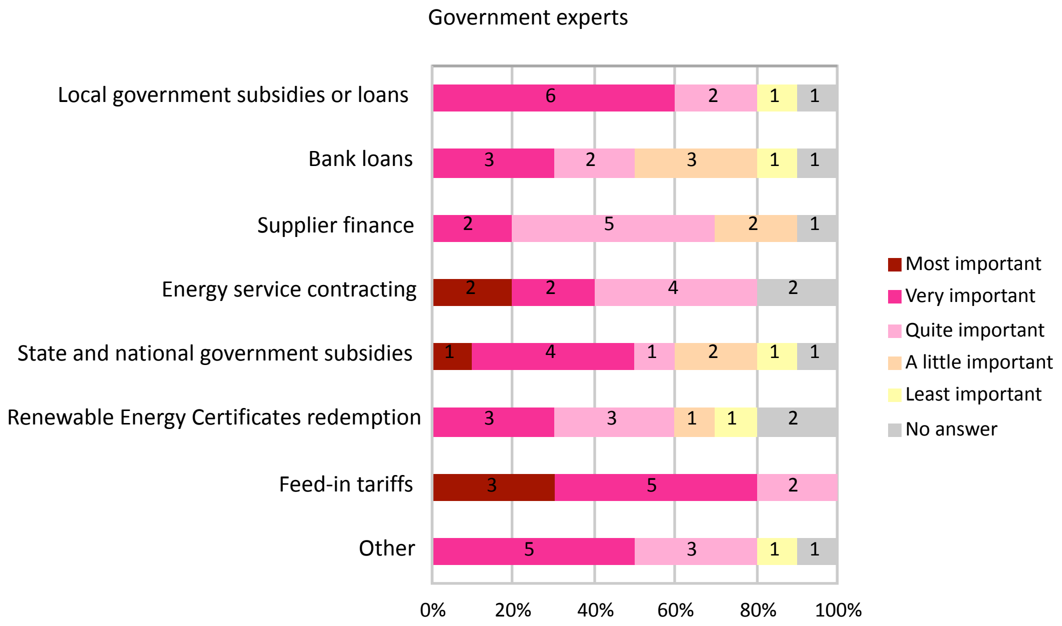


Fig. 57. Number and percentage of experts rating financial measures.





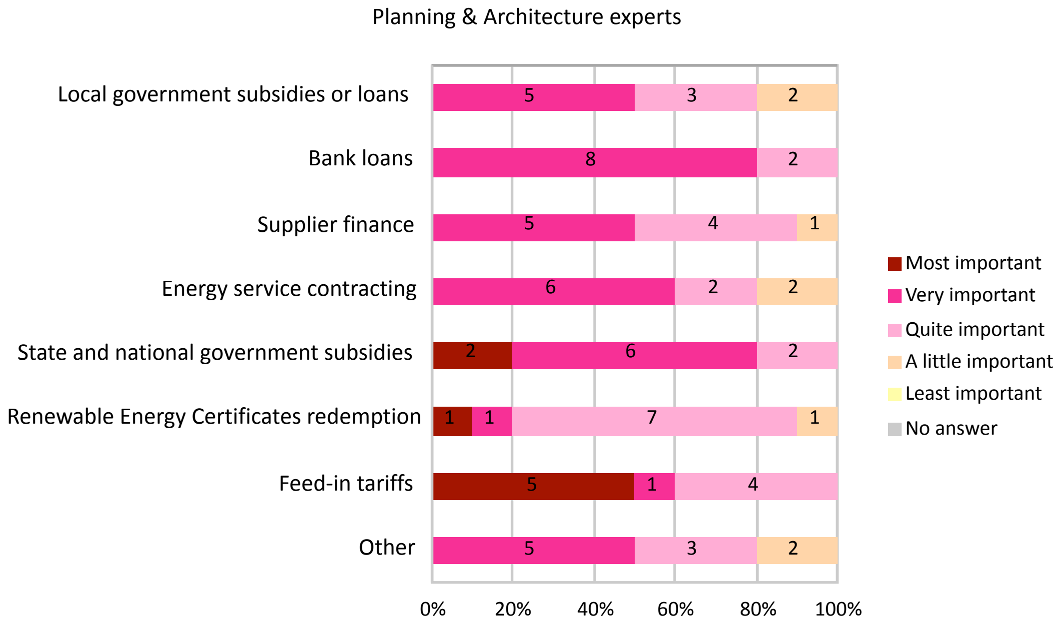


Fig. 58-59-60. Number and percentage of experts rating financial measures according to profession.

The results showed that feed-in tariffs were regarded as the most important financial measure. Government financing schemes such as state and national government subsidies, energy service contracting and renewable energy certificate redemption were most likely to gain positive responses over private enterprise schemes such as bank loans and supplier finance. Local government subsidies and loans tended to rate the least important of all measures. Experts from each of the professions rated feed-in tariffs to be the most important. It is interesting to note that the preferred measure following feed-in tariffs differed between experts. Experts from planning and architecture tended to support state and national government subsidies. Government experts were inclined towards energy service contracting. While, energy experts preferred both of these aspects equally. Interestingly, government experts were most likely to be uncertain as to the importance of each proposed method compared to other experts, as shown in higher number of non-responses. Other financial measures suggested by experts included philanthropy, calculation of "regional debt" for renewable energy, and regulating the relative price of fossil energies (e.g. taxes on carbon emissions).

Based on the responses, the *financial* measures can be listed in order of significance:

1. Feed-in tariffs
2. State and national government subsidies
3. Energy service contracting
4. Local government subsidies or loans
5. Bank loans
6. Renewable energy certificates redemption
7. Supplier finance
8. Other

Legal measures

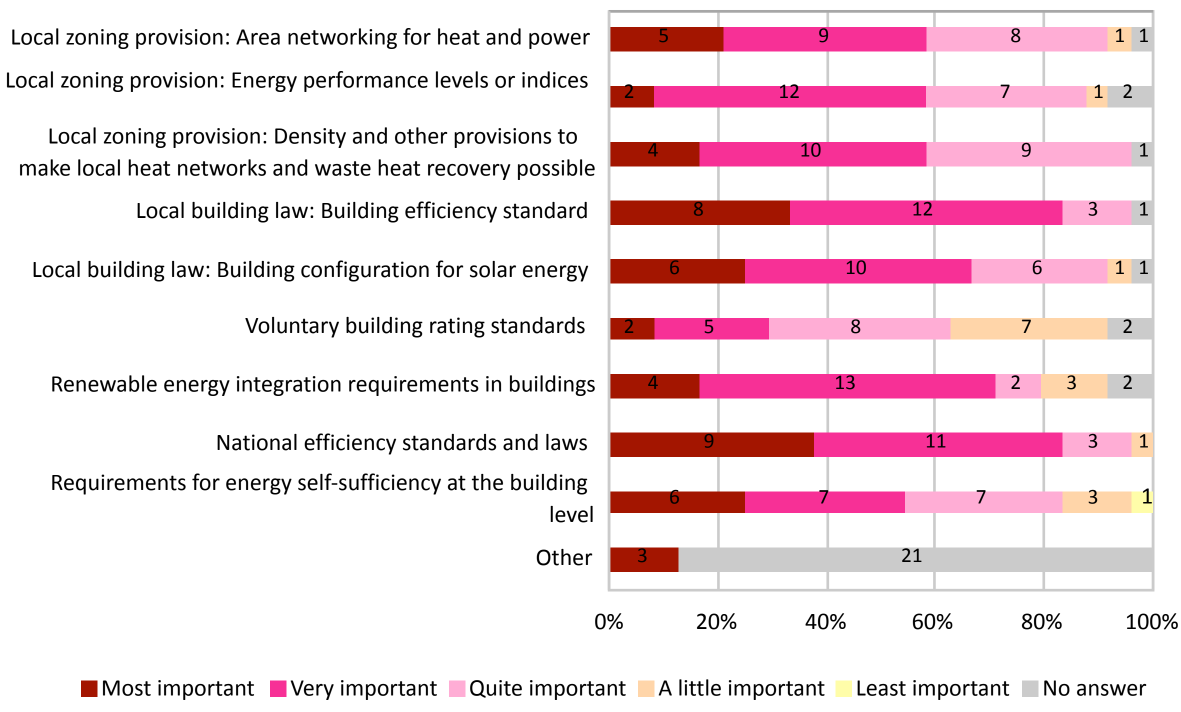
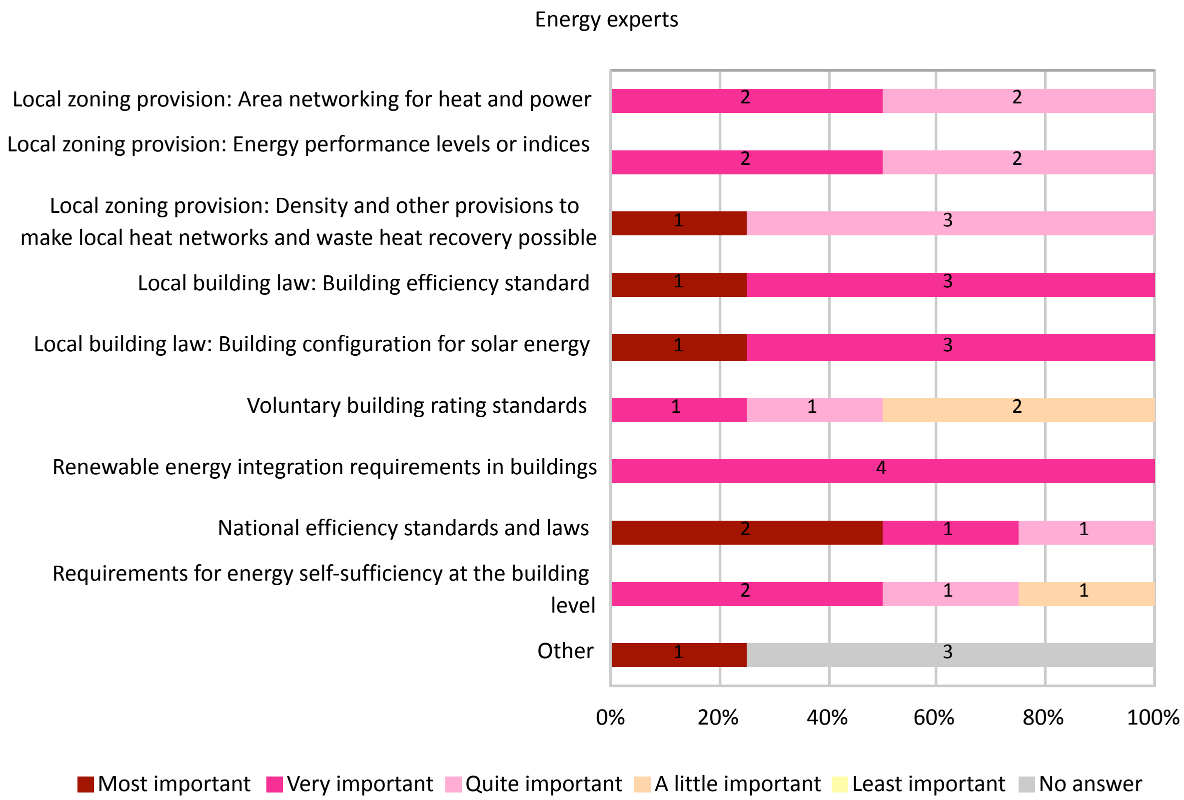
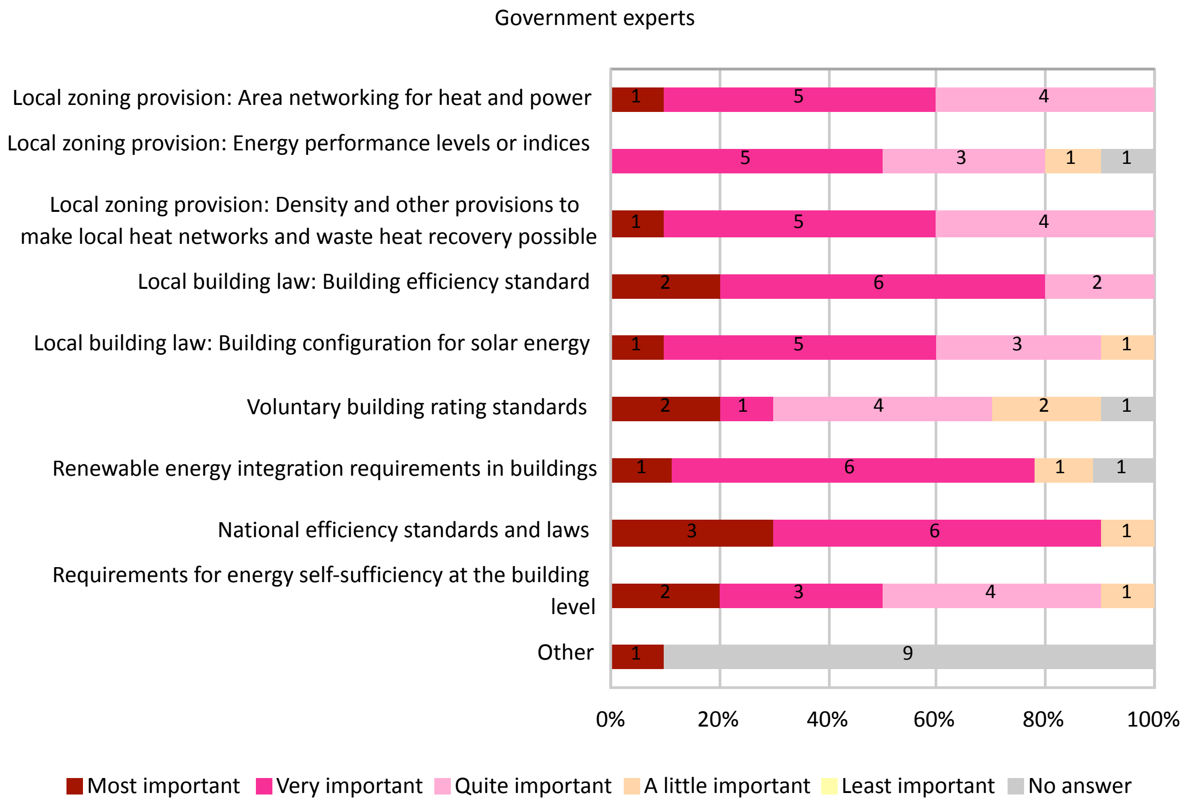


Fig. 61. Number and percentage of experts rating legal measures.


Energy experts
Local zoning provision: Area networking for heat and power
Local zoning provision: Energy performance levels or indices
Local zoning provision: Density and other provisions to make local heat networks and waste heat recovery possible
Local building law: Building efficiency standard
Local building law: Building configuration for solar energy
Voluntary building rating standards
Renewable energy integration requirements in buildings
National efficiency standards and laws
Requirements for energy self-sufficiency at the building level
Other
0%
20%
40%
60%
80%
100%
Most important
Very important
Quite important
A little important
Least important
No answer


Government experts
Local zoning provision: Area networking for heat and power
Local zoning provision: Energy performance levels or indices
Local zoning provision: Density and other provisions to make local heat networks and waste heat recovery possible
Local building law: Building efficiency standard
Local building law: Building configuration for solar energy
Voluntary building rating standards
Renewable energy integration requirements in buildings
National efficiency standards and laws
Requirements for energy self-sufficiency at the building level
Other
0%
20%
40%
60%
80%
100%
Most important
Very important
Quite important
A little important
Least important
No answer

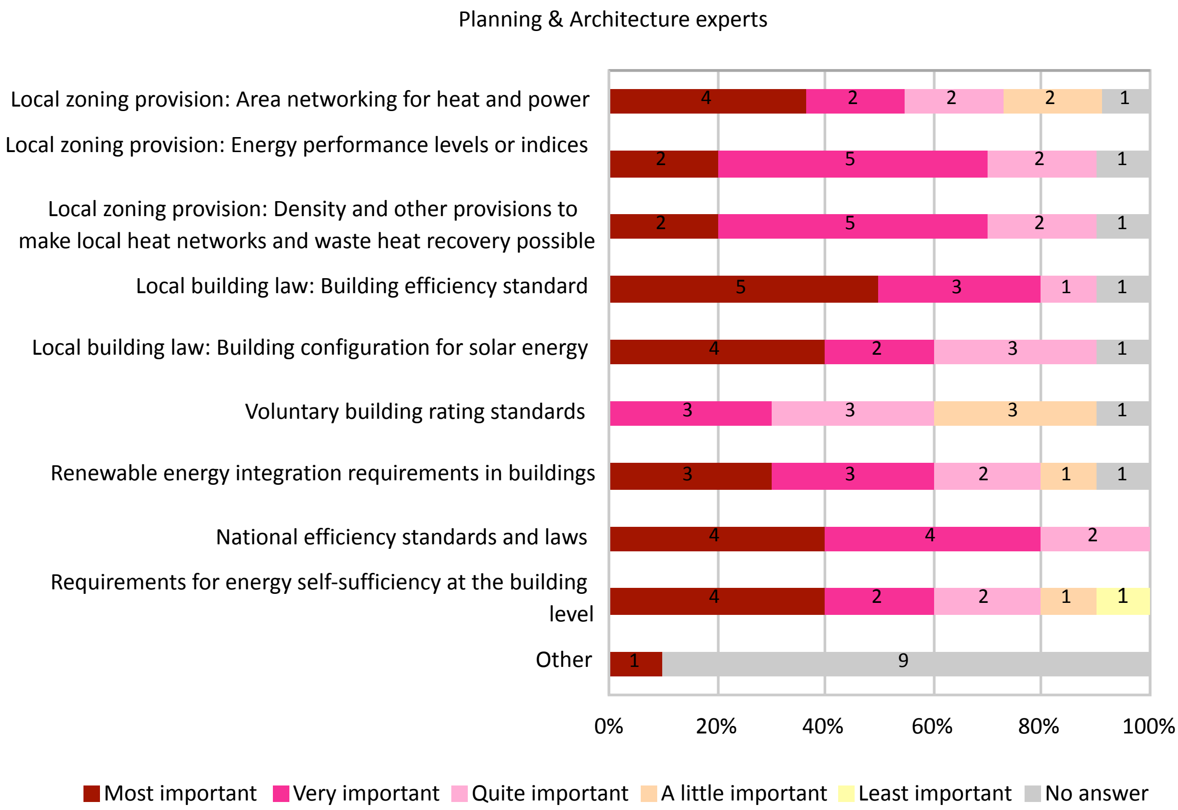


Fig. 62-63-64. Number and percentage of experts rating legal measures according to profession.

National efficiency standards and laws were regarded as the most important legal measures for pursuing energy autonomy. The measure that tended to rate the lowest was voluntary building rating standards. Interestingly, experts from planning and architecture were the only group to rate local building efficiency laws higher than the national standards. Government experts tended to lean towards national measures compared to planning and architecture experts who favoured local provisions. They were also the only group to see merit in voluntary building rating standards. Local zoning provision that indexes energy performance of areas, although preferred by planning experts, was least likely to be supported by energy and government experts. Other measures suggested by experts included identifying urban and building “typologies” designed for optimizing renewable energetic autonomy, making a chart of the local energy balance, and mandating the retrofit of all existing buildings.

Based on the responses, the *legal* measures can be listed in order of significance:

1. National efficiency standards and laws
2. Local building law (building efficiency standard)
3. Local building law (building configuration for solar energy)
4. Renewable energy integration requirements in buildings
5. Requirements for energy self-sufficiency at the building level
6. Local zoning provision (area networking for heat and power)
7. Local zoning provision (density and other provision to make local heat)

8. Local zoning provision (energy performance levels or indices)
9. Voluntary building rating standards
10. Other

3.4.4 Question 3: How do you rate the recommended capacity measures for energy autonomy?

Staff & Budget

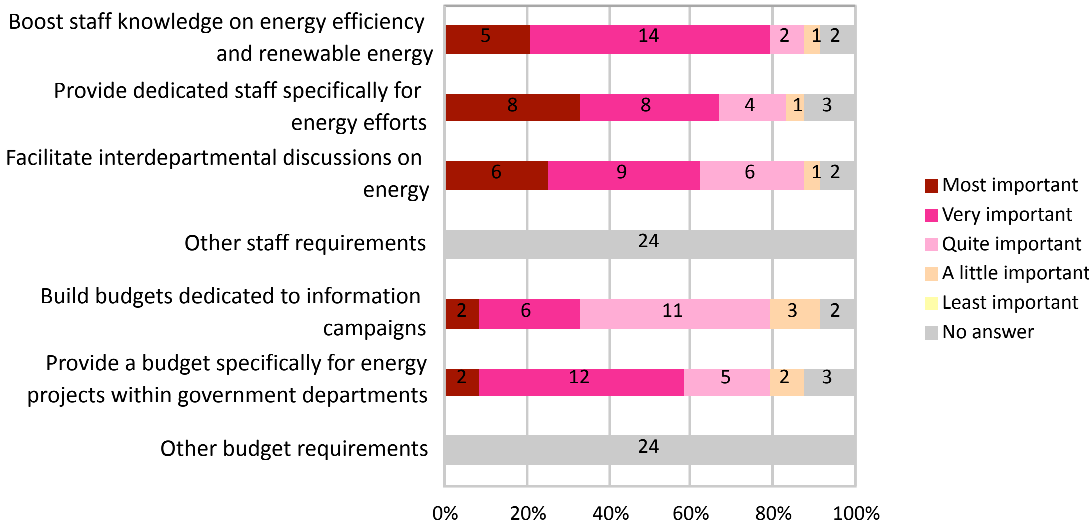
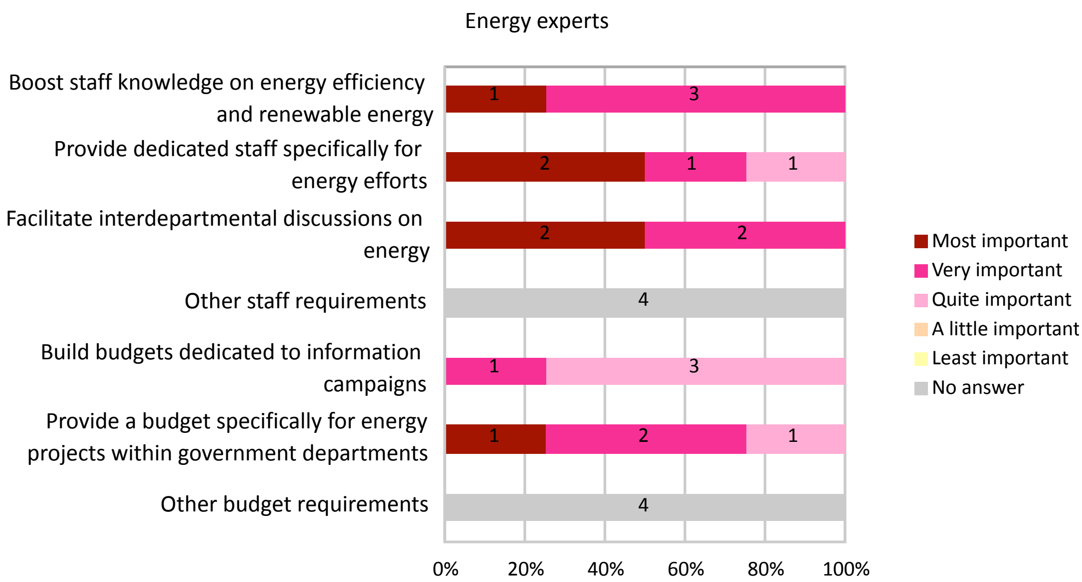
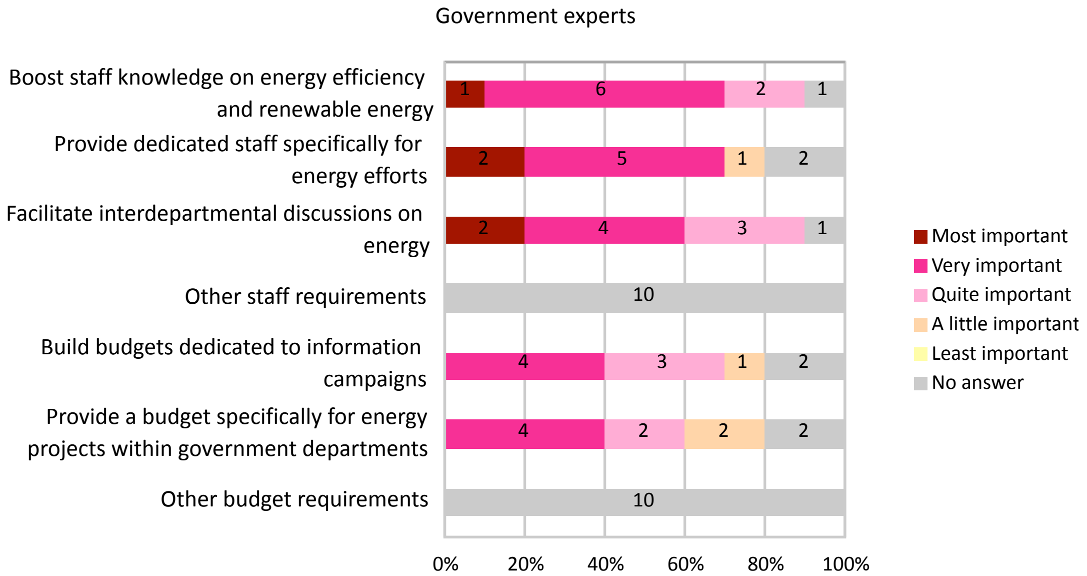


Fig. 65. Number and percentage of experts rating staff and budgetary measures.





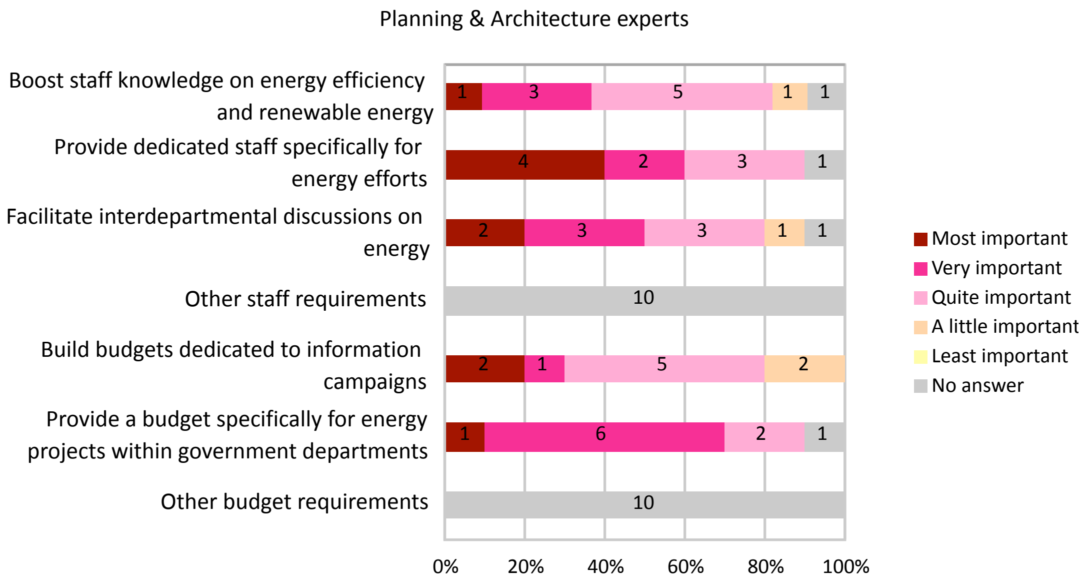


Fig. 66-67-68. Number and percentage of experts rating staff and budgetary measures according to profession.

The most important measures were providing dedicated staff especially for energy efforts, and a budget dedicated for energy projects within government departments. In terms of staffing requirements, only energy experts rated the facilitation of interdepartmental discussions on energy higher than just the provision of a dedicated staff. In relation to budgets, government experts were most reticent to build budgets for information campaigns or for specific energy projects, compared to other expert groups. No other measures were suggested by any of the experts.

Based on the responses, the *staff and budgetary* measures can be listed in order of significance:

Staff measures

1. Provide dedicated staff specially for energy efforts
2. Boost staff knowledge on energy efficiency and renewable energy
3. Facilitate interdepartmental discussions on energy

Budgetary measures

1. Provide a budget specifically for energy projects within government departments
2. Build budgets dedicated to information campaigns

Organisational measures

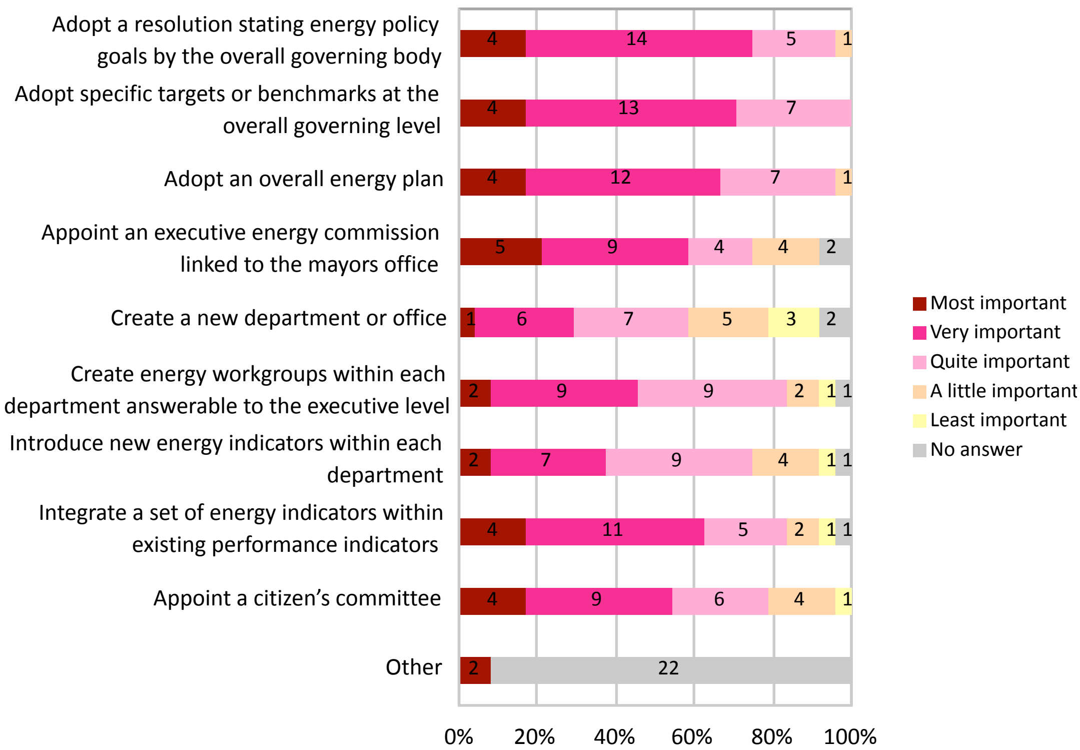
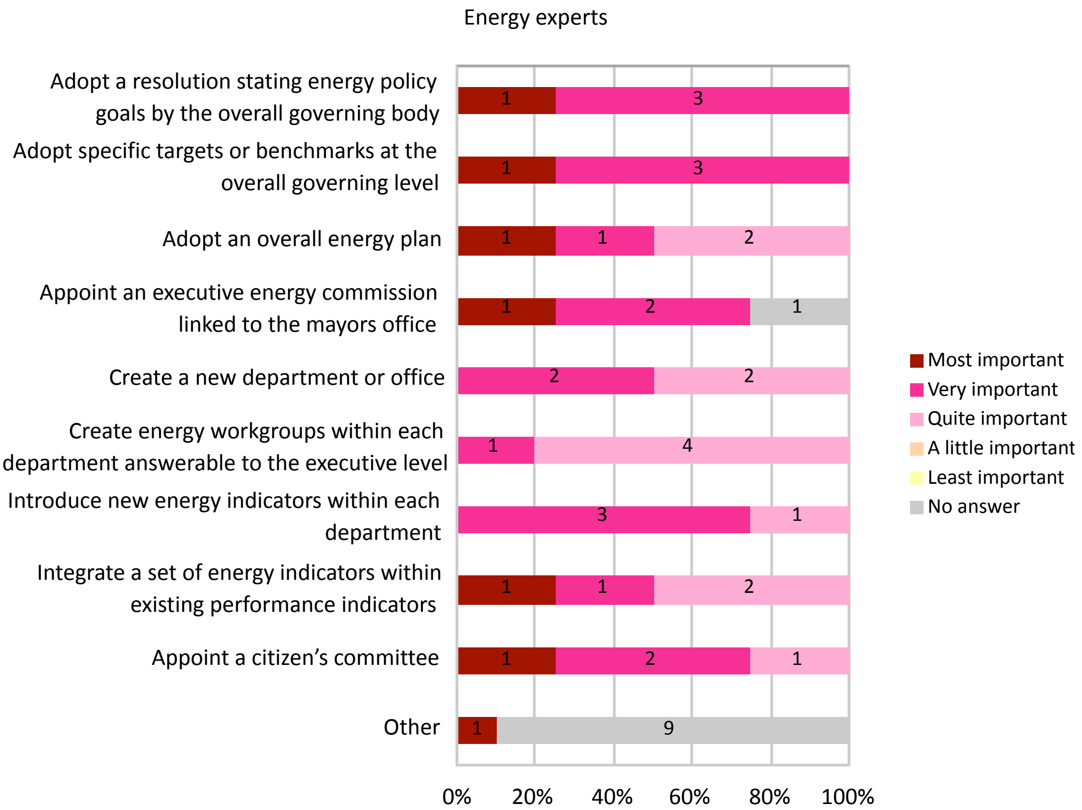
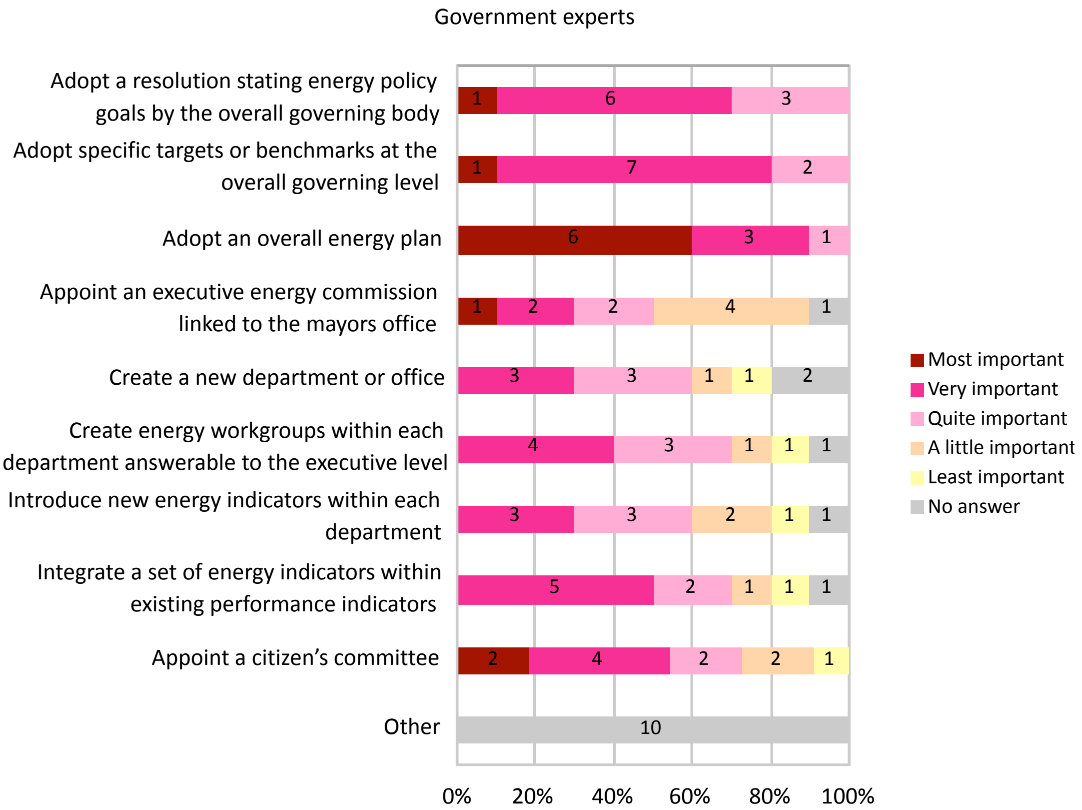


Fig. 69. Number and percentage of experts rating organisational measures.


Energy experts
Adopt a resolution stating energy policy goals by the overall governing body
Adopt specific targets or benchmarks at the overall governing level
Adopt an overall energy plan
Appoint an executive energy commission linked to the mayors office
Create a new department or office
Create energy workgroups within each department answerable to the executive level
Introduce new energy indicators within each department
Integrate a set of energy indicators within existing performance indicators
Appoint a citizen's committee
Other
0%
20%
40%
60%
80%
100%
Most important
Very important
Quite important
A little important
Least important
No answer


Government experts
Adopt a resolution stating energy policy goals by the overall governing body
Adopt specific targets or benchmarks at the overall governing level
Adopt an overall energy plan
Appoint an executive energy commission linked to the mayors office
Create a new department or office
Create energy workgroups within each department answerable to the executive level
Introduce new energy indicators within each department
Integrate a set of energy indicators within existing performance indicators
Appoint a citizen's committee
Other
0%
20%
40%
60%
80%
100%
Most important
Very important
Quite important
A little important
Least important
No answer

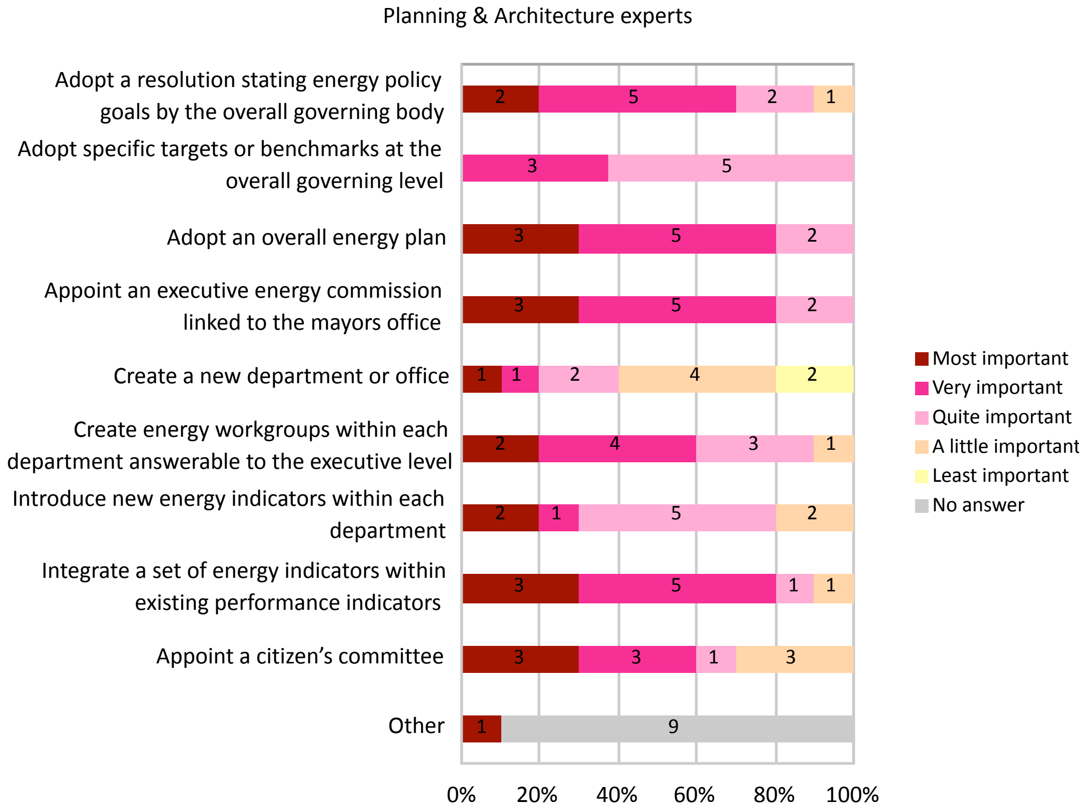


Fig. 70-71-72. Number and percentage of experts rating organisational measures according to profession.

The creation of an executive energy commission linked to the mayor's office was rated the most important measure. The least significant of the specified measures was to create a new department or office. Energy and government experts tended to steer away from measures that involved creating new groups or entities to especially manage energy. Setting energy indicators within existing performance indicators was least likely to be supported by government experts. Other suggested measures included creating an "interdisciplinarity of knowledge" within architectural and urban development practice that integrates physical, technological and functional components with a new environmental approach; and integrating local businesses, research/education or the financial sector in local government decision-making.

Based on the responses, the *organisational* measures can be listed in order of significance:

1. Appoint an executive energy commission linked to the mayors office
2. Adopt a resolution stating energy policy goals by the overall governing body
3. Adopt specific targets or benchmarks at the overall governing level
4. Integrate a set of energy indicators within existing performance indicators
5. Adopt an overall energy plan
6. Appoint a citizen's committee
7. Create energy workgroups within each department answerable to the executive level
8. Introduce new energy indicators within each department

9. Create a new department or office
10. Other

3.4.5 Second round summary

In the first round, the concept of energy autonomy elicited several sceptical responses (n=6). Despite the term being clarified in the second round of questioning, the negative views of energy autonomy remained (n=5). The issue did not so much concern the energy source or technology, but the scale and geographical context of energy autonomy. Experts argued that *local* energy autonomy is achievable in small, rural villages, but almost impossible for big cities where population size and energy demands outstrip the availability of land and building surfaces for renewable energy generation and storage.

(In this dissertation, local energy autonomy does not mean meeting local energy demand met exclusively with renewable energy generated within local government boundaries. Rather, it denotes local commitment and action that aims to substitute local fossil energy, first with energy from local renewable sources and then, from external renewable sources, where external sources refer to the renewable energy supplied through regional and national renewable energy networks and storage systems.)

The results of the second round revealed that in terms of regulations, legislation and standards – the aspects deemed most significant to achieve energy autonomy in the first round – experts tended to rate national efficiency standards and laws most significant. Generally, building standards were preferred over area-based laws such as local zoning provisions. Government experts were the only group to see merit in voluntary building rating standards. These experts also tended to lean towards national government measures before implementing local standards in comparison with experts in energy or architecture and planning, who strongly preferred localised measures in the form of area networking for heat and power, density, other local zoning provisions for local heat and local energy performance levels or indices. Other legislation that frequently rated the highest included feed-in tariffs and regional and national subsidies. Government financing incentives were generally more preferred than private financing mechanisms. This shows an overall strong centralised bias.

In the first round, institutional reform in relation to strategic and general planning practices was rated the least significant. This opinion was reiterated in the second round, as shown in the weaker support for area-based zoning provisions when compared to building laws, particularly so by government and energy experts.

In the first round, experts agreed that local government's limited knowledge of energy influences the way energy issues are prioritised within the administration. In the second round, the responses indicated that energy remains prioritised as a technical phenomenon rather than as a conceptual vision. The preference to educate or to inform - deemed highly significant in the first round – was overshadowed by financial- and project-based concerns in the second round. In the survey, boosting existing staff knowledge on energy efficiency and renewable energy or undertaking community information campaigns were not rated as significant as providing additional and dedicated staff for energy, or instigating interdepartmental discussions and reporting. Such campaigns were also not favoured to receive especially dedicated budgets as local energy projects. The imbalance in priority is affirms experts' arguments in the first round that the improvement of municipal practices in energy efficiency and renewable energy should also not interfere greatly with other existing tasks.

Although experts were more likely to support the creation of a separate energy development entity to pursue renewable energy autonomy over government restructuring in the first round, the second round revealed that changes to the existing government organisational frameworks was much preferred, but in the form of an executive energy commission that was linked to the mayor's office.

There was little support for new departments or offices dedicated especially to managing energy, and even less than the appointment of a citizen's committee. The latter of which confirms the importance of local stakeholder integration as emphasised in the first round before the development of separate entities to pursue energy autonomy.

3.5 Discussion

3.5.1 Response to Research Question 2

Research Question 2 as formulated in Chapter 1 stated:

'In relation to implementation, what requirements should be most critically considered with respect to governing urban development for local energy autonomy?'

I found that the six most critical factors when governing urban development for local energy autonomy, based on the results of the Delphi Survey were (in no particular order):

1. Understanding the level of local government awareness of energy autonomy issues and capacities, including the reasons for positions held for or against energy autonomy that follows from a clear clarification of terms in the context of local community and government,
2. Appreciating and working with the influence of central government on local action in energy projects, with respect to regulations, legislation and standards in a planning, organisational and financial sense,
3. Seeking local government discretion to implement actions that directly pursue the goal of energy autonomy,
4. Analysing and utilising the existing local government structure, with augmentation to existing structures through public-private partnerships
5. Considering the role of the local leaders to motivate and to mobilise implementation - and
6. Creating a local energy potentials model by local government.

3.5.2 Local government measures to achieve energy autonomy

Building on the first four of these messages, it is useful to base the discussion precisely on the key question asked at the beginning of this chapter (see Context 3.1):

1. What measures can local government take to achieve renewable energy autonomy?

Nurture awareness - of the issue and one's own capacities

The Delphi survey revealed agreement among experts that, above all, an awareness of 'energy autonomy' needs to be instilled. Municipalities need to understand what energy autonomy means for themselves, their community, their economy and their environment. Municipalities can engage external parties in form of consultants and researchers to help them assess these impacts as well as what benefits that energy autonomy can bring. They can gauge the limits of their own working capacity to pursue the energy projects necessary to achieve energy autonomy. They can evaluate their role as a local government entity, the ability to adjust or to add, as a group or as individual actors within the municipality. They can assess their ability to be leaders of the vision, and undertake municipal energy autonomy actions as an example for the rest of the community to follow. They can also seek inspiration from other municipalities, talking to others who have achieved more ambitious energy targets. The motivation to do better is prompted when municipalities begin to compare themselves with others, particularly those who have already achieved energy autonomy. Peer pressure can eventually compel municipalities to rethink their preconceptions and embrace the goal. But to affect a paradigm shift from the “servicing” mode to the “innovating” mode in the first instance will be difficult, but local governments can begin to pursue this through interdepartmental discussion and community participation. This would also entail some analysis of what they can achieve within their jurisdictional or legal limits, boundaries usually set from higher levels of government.

Education and training

According to many experts, local government can prioritise the education or training of its own administration and then the rest of the community. I believe this aspect will become more significant as energy continues to be a central concern for communities in the face of economic crises and a changing climate. The educating and training of local government can provide a new broader insight and technical knowledge on the fundamental aspects of energy supply, demand and type in order to dispel the negative preconceptions of energy autonomy and to create an awareness that local government plays a very important role in driving the local energy transition.

Educating and training through workshops with researchers, central government officials and community stakeholders can compel local governments to rethink their responsibilities beyond the focus on *outputs* in the form of “roads, rates and rubbish” to **“**outcomes”, in the form of “strengthening” and “innovating” the municipality. In order to influence opinions and induce practical actions, local government can structure awareness raising or retraining rather than engage in activities that passively disseminate information. It no longer concerns making information available – through websites, leaflets, brochures, reports – so much as ensuring active community engagement – through workshops, seminars and info days with experts. This is because energy autonomy is not just a question of sensitivity, moral responsibility and agenda setting, but also concerns establishing participatory business models to deliver innovative local urban development, a model different to that of the municipal-led “servicing” mode. The information itself should also be correct, up-to-date and relevant.

Investing in a paradigm shift

Many experts understood that energy autonomy was less a matter of available space and technical capacity, but one of finance, and ideology. Since budgetary issues will always be a universal concern for governments, which often constricts and dampens the capacity to act, it was therefore unsurprising amongst experts for the need for redistributing resources by local government that support projects in pursuit of energy autonomy– resources that are in constant competition with other governmental priorities.

Meanwhile energy autonomy as an ideology, seen by some as potentially controversial because it connotes *political aims,* means that the term calls for a succinct definition that also clearly explains its priority, its energetic assumptions, its territorial reach, its users, its measurement and moreover its benefits. The emphasis on ‘politics’ is not so much to do with imposing targets or tasks but rather to emphasise that local energy supplies must be allowed to be managed by the local municipality or its local community for the benefit of the entire locality. Energy autonomy has to be explained not only as a definitive energy target but also as a vision or ‘ethical imperative’ (Scheer, 2010) for which actions in the mean time are guided and prioritised. For most experts, the concept of energy autonomy was rather novel - vaguely understood by most or completely rejected by a few. Consequently, the challenge for local governments is to be able to formulate an energy strategy that clearly and simply explains the definition, which is adapted to the local context, and is accompanied by a set of practical measures that benefits the community.

The level of understanding of energy autonomy will undoubtedly influence the willingness of governments to implement any changes to normative practices that could contribute towards pursuing this vision. It would effect how adjustments would be made to current urban development in driving energy autonomy, while the resultant measures must be flexible enough to adapt as technologies develop and attitudes evolve. However it also calls for energy autonomy to be set as strategic and binding policy by local government in the first instance in order for operationalisation to begin.

Reform, regulate and implement

According to more than half of the experts, local governments can make use of existing, often under-utilised national *guidelines* for governing energy efficiency and renewable energy, although this may also mean finding out whether these actually exist. Some may not even be aware of possible incentives for municipal or community development projects, either from the national, regional or European levels of government. However, if indeed no guidelines or incentives exist, or those in existence are shown to be inadequate, municipalities can develop their own or amend existing codes to integrate more stringent energetic criteria. There is potential to develop own local energy planning rules, energy potentials maps, or guidelines for renewable energy technology integration.

Local government can pursue the development of municipal energy plants or energy cooperatives in partnership with the local community to manage the implementation of a range of renewable energy technologies in the locality. The demonstrations of their capacity to plan, finance and manage such projects can be used to convince and lever support from the rest of the community, including businesses, industry and the national government. Local strategies can become important lobbying pieces to influence national action and support, especially if local governments can also demonstrate that these contribute to the overall *national* energy target.

Based on expert comments, municipal spatial planning practices would have to evolve in order to pursue energy autonomy, especially as awareness increases of their energetic possibilities. In my estimation, such transformations in planning will manifest in a variety of ways. For instance, it may be inevitable that traditional evaluations of individual projects will be replaced by a network-based approach to consenting development that optimises energy potentials of areas. I foresee that in place of traditional land-use planning and building codes, integrated local capacity energy strategies will encourage mixed-use planning and development, organised according to the infrastructure and distances required to optimise energy efficiency and renewable energy integration. Instead of specifying 'minimum' standards for building construction that only serve to designate the 'maximum' limits in energy efficiency and renewable energy that are sufficient to reach specific energy ratings, improved local codes and other policy provisions can promote an ‘unlimited’ approach to achieving energy autonomy - subject of course to design, environmental and conservation standards. In the administration of urban development, lengthy waits to gain development approval for local energy projects can be replaced by a more efficient planning consent process that engages the local communities with the local government from the first moment a project is initiated – displacing the traditional ‘propose-object-defend’ mode.

To really drive implementation, local government can fast-track special energy projects and set more stringent certification processes that also promises reward in form of municipal and industry awards or municipal and State grants or rebates. It is essential, based on the expert opinions, that existing incentives in form of financial contributions or planning and development rights remain relatively consistent and in place for significant periods.

Administrative adjustments

In organisational terms, local governments can promote, or raise the position of existing energy commissions/workgroups or planning officers whose responsibility for energy has been too deeply buried within existing environmental, planning or building departments, and realign them with the mayor’s office. Ideally, an energy commission should be chaired by the mayor, its role elevated, and given the authority to ensure that energy autonomy as a target is understood and supported by all municipal departments, and that each sectoral action would contribute to achieving this goal depending on the department's responsibility. As an umbrella entity across all departments, the commission would then be better placed to enforce more definitive targets. This may require additional staff.

Although experts in the survey did not generally support departmental performance indicators, local government can set basic energy performance targets that contribute to the overall energy autonomy goal. This may be reinforced by the introduction of new protocols for interdepartmental exchange, measuring, reporting and rewarding. The local government can also restructure the new energy commission in such a way, which allows the community to also participate in the development of the local energy autonomy strategy. This could take place through for example, the planning of special local energy infrastructure projects, the engagement of private and community financing through industry alliances, the development of local school curricula, or the promotion of community energy events and activities.

If there is yet to be an energy commission, local government can install a group that would directly develop the energy autonomy vision with and for the local community as well as an integrated action plan that ensures the participation of all departments. Ensuring the necessary and correct staff is essential as well as prioritising the budget for energy autonomy. Silos and division of sectors are to be avoided if energy autonomy is to be achieved, according to the experts. Further adjustments may be required if local governments also consider regaining control over their local energy infrastructures and services either wholly or partially. At this stage, the dual responsibility for policy development and compliance, alongside technical and operations management, become complex and necessary tasks for the local energy commission to tackle.

Indeed, new local government responsibilities in energy autonomy would require assistance, cooperation and feedback from national government in order for efforts in energy efficiency and renewable energy not to be duplicated, and for municipalities to be aware that central support is at least provided for certain critical purposes. If appropriate support is not sufficient and local government structures are shown to be incapable, local governments can pursue the creation of a separate energy development entity to pursue renewable energy autonomy. This can be achieved through the establishment of partnerships with external energy advisory parties.

Empower local government

Several experts expressed the need for devolving power to local government to enable them to be pro-active and take control of their own planning and infrastructure to pursue energy autonomy, even despite the weariness shown by central governments in losing control, and the reluctance shown by most local governments in acquiring extra responsibility. In the case of the municipality, most experts agreed that energy planning has not been traditionally seen as a matter of local government concern or expertise. Historically, they have had no say in energy policies or energy infrastructure management, aspects which were normally centralised. This reluctance has been subsequently reflected in a general unwillingness to pursue the implementation of energy-related infrastructure combined with a routine preference for providing *advisory* services.

I believe that despite the known difficulties when undertaking new tasks and establishing reforms, local government can, and have achieved great success in energy initiatives, even after having been historically curtailed by the lack of power devolve to them by the State. The 1980's 'Thatcherite' model of lean, privatising, outsourcing government based on notions of self-help still resonated in many expert opinions - but only in the sense that local governments can function as 'businesses' or 'enterprises' in themselves, through the control of their own local energy agencies, energy service companies or the management of community energy cooperatives. However, local government must ascertain whether they have the constitutional right to do so, and if not, begin to lobby the community and other local governments for adjustments to rules defining municipal autonomy responsibility.

Despite the call for self-help, external assistance is still essential - and national government leadership plays a major role in this. It can focus the goal of energy autonomy as an *institutional strategy* and create stable and flexible legislative frameworks to support this goal at *multiple* levels of government. Following institutional support comes the need for technical support to translate the strategy into meaningful actions, which local governments can source from academic institutions and independent energy advisors.

3.5.3 Use of visual models in making local energy autonomy capacities understandable

The second question at the beginning of this chapter (see Context 3.1) asked:

2. 'What attributes should local energy autonomy modelling tools have in order to be useful towards achieving this goal?'

This question relates directly to the final message I distilled from the Delphi survey in response to Research Question 2 (Discussion 3.5.1 above). According to the experts, a local energy autonomy modelling tool should have the ability to not only visualise energy potentials of areas but also account for future energy savings or even energy performance data of individual buildings and the energy supply networks supplying them. It should be able to function with other models that take into account criteria such as economic feasibility of renewable energy supply infrastructures (installations, electricity grid use and transport costs), impact of available incentive programs and subsidies, calculations of local economic value creation (job creation and supply security), value or price of energy at different times, or policies regulating land-use planning, conservation and landscape. In order to incorporate the many local attributes, the participation of local government in its development is essential.

Ensure legibility, immediacy and openness

Most experts emphasised that the visualised benefits needed to be immediate to local government and the local community. One expert noted that by embedding information on existing floor space, plant equipment and fabric performance of individual buildings, local governments would be able to project future building spaces and hence help plan for the management and utilisation of renewable infrastructure as an urban network of buildings and sites, rather than the planning of buildings as singular entities. A future version of STEM could not only take into account single renewable energy installations, but entire generation-storage-use complexes in the form of virtual power plants/systems (VPP/VPS). By including calculations on local economic value and value capture, the model could also help convey the advantages of local energy supply over energy imports. By coordinating the tool with local market conditions and players, institutions and markets could become more adequately aligned. The model could also maintain a degree of transparency, enabling the placement of relevant energy data in the public domain. It is most likely that a local government energy model would be able to display data such as energy consumption and energy-savings potentials publicly, data otherwise protected by energy companies or utilities for commercial reasons.

Facilitate outcome orientation and decision support

According to the experts, a local energy autonomy modelling tool should ultimately be future-oriented and stakeholder-involved. By highlighting and comparing community benefits, it should help local government set priorities in the mobilization of financial resources and the construction of the necessary renewable energy infrastructure. It should be able to provide important background information for shaping public opinion and political debate. It should ultimately be relevant to local government concerns and be accessible to other professionals from within local government, such as landscape planning and transportation, to ensure the mutual understanding of goals.

An ability to compare the state of implementation with first estimates or early projections however requires a continually developed version of the tool to allow comparisons with its superseded versions. One method to measure this is by using *dynamic models as opposed to static models*, in order to visualise real-time changes. (The local energy autonomy modelling tool STEM referred to in this dissertation only provides static maps for analysis). According to one expert, a continuous adaptation of the initial scenario should be made in line with monitoring protocols, taking into account the kind of information the model already contains, the kind of instruments already used, as well as the budgetary, technological and institutional constraints. These would help the testing of energy efficiency and renewable energy scenarios at the initial stages and then over time, either validating the plan or pin-pointing the need for readjustments/refinements in existing environmental planning frameworks such as ISO14000, LEAP, or other existing building codes and urban planning standards.

However, I was reminded that a local energy autonomy modelling tool can only provide guiding estimates and planning support, since it is based on informed, conceptual assumptions. It may not be compatible or work well with existing political-bureaucratic systems which function in an entirely manner to IT enabled real-time decision support structures. According to one expert, it cannot compensate for missing drivers, inadequate local commitment or incentives, or all-too rudimentary national incentives.

3.5.4 Summary of surveys based on professional expertise

Energy experts were the most optimistic with regards to the measures mentioned in the survey. They rated high to very high: regulations, legislation and standards; institutional reform of strategic and planning practices; partnering; the integration of energy into performance indicators; and the creation of a separate development entity for energy autonomy. Although reform was supported, they also tended to agree that the local government structure did not have to significantly change to pursue energy autonomy. Compared to other experts, they were most likely to support the idea of simply instigating department discussions in pursuit of this goal. One could argue that the general optimism shown by the energy experts can be attributed to their better understanding of the technological and financial requirements for energy autonomy, based on their academic as well as practical experience, or due to their usual 'can do' outcome-oriented, technical attitudes. The lesser awareness of institutional impacts that may have also driven them to support reforms of existing planning practices, therefore resulting in a generally optimistic view of governance.

Planning and architecture experts mostly favoured incentives. There was a consensus amongst them that these should be consistent in terms, relatively long lasting, and flexible to market influences. In this view, incentives can induce pressures and forces that are more effective than regulations, which most agreed can be rigid and unpopular; or partnering, which may rely on short-term contractual obligations and enable partners to ‘opt out' at different stages; or information and education, which may be unreliable and quickly out-of-date. However, very few experts explained how the lasting management of incentives towards a common goal over the long term would ultimately be ensured, except for a handful, which noted the need for bi-partisan support in order for successive governments to continually maintain them. It was not surprising that the planners and architects did not rate highly the reform of strategic planning and practices, showing very little support for energy performance indicators within government, since these would entail ‘extra' work and other legal hurdles that local government planners would have to negotiate. Although planning reform was *not* generally supported, the planners and architects still backed the idea for creating local provisions to index the energy performance of areas, more so than other experts.

Government experts were most likely to rate highly regulations, legislation and standards local government restructuring. However it is interesting to note that in the first round, these alongside incentives were considered too short-lived despite their strong and direct effects, compared to planning reform, partnering or education. The latter measures were seen to be more diffusedly effective but better for the long-term pursuit of energy autonomy due to their transformational potential. In the second survey, government experts preferred national codes to local ones, and financial incentives in the form of (national) feed-in tariffs over (local) supplier finance. This surprised because it seemed to contradict the many comments and arguments in the first survey for more localised implementation and private investment to support more distributed forms of energy generation. Government experts also preferred budgets dedicated to energy projects rather than information campaigns, and were most likely to support voluntary building standards compared to other experts. The creation of new groups to pursue energy autonomy, or installing energy performance indicators within the administration, were generally not favoured.

Chapter 4. International cases

This chapter presents an analysis of three municipalities in Europe that have achieved energy autonomy. The results aim to inform a municipal framework for realising local energy autonomy potentials.

The work conducted in this chapter began in 2010 as an examination of how the actions of actual energy autonomous municipalities corresponded with the World Future Council (Droege et al., 2010) criteria for 100% renewable energy communities, as part of its 'Urban renewable power policy toolbox'. The findings were published in the book 'Climate Change Governance' as a chapter on governing tools for local energy autonomy (Radzi & Droege, 2013). Following the publication, the findings were re-examined and extended to focus on six critical factors, which were synthesised from the results of the Delphi expert survey conducted in Chapter 3. This enabled the determination of whether actions on the ground actually corresponded with expert opinion with regards to pursuing local energy autonomy. It examined the actors involved, the attitudes to realising technical and theoretical capacity for energy autonomy, and the modes of governance. With particular reference to urban planning practices in energy autonomy, this chapter examines the ways in which local communities can act through their government and administrative apparatus.

4.1 Context

Half of the commercial energy supplied worldwide is used for urban areas. The vast majority of this unsustainable resource flow consists of fossil fuels: almost all of global mechanised transport depends on petroleum (EIA, 2006; IPCC, 2007). The burning of coal and oil helped to boost atmospheric CO_2 concentrations by almost 40% beyond their long-stable level of 280 parts per million. Given such statistics, the immediate curtailment of new emissions, and the biological re-sequestration of existing concentrations are of critical importance. The aim of mitigation through the removal of fossil fuel content in energy supplies, the source of 85% of all anthropogenic greenhouse gas (GHG) emissions (IPCC, 2007) is thus central to the idea of this chapter. Emergency actions are called for at all levels of society and economy. Central roles in this historical struggle fall to the governance of local municipalities: the very logic of renewable energy implies that a large degree of the required energy transformation is accomplished locally and regionally. With national and supra-regional renewable supply networks serving as support, local and regional autonomy in renewable energy supplies can help urban areas escape from fossil fuel and nuclear dependency.

It is important to note that public administrative institutions have historically evolved in a time of escalating and now near-total reliance on seemingly abundant fossil fuels and uranium. Profuse supplies allowed the proliferation of road networks, enabling rapid urban sprawl, and encouraging the consumption of goods and services at an accelerating rate. It also engendered the disaggregated use of land, where people no longer had to live close to their place of work or where they purchased their daily groceries. Energy networks and remote energy sources controlled by large-scale, all-powerful regional or national monopolies have meant that influence on energy distribution or prices at the local level have been minimal. Combined with the disaggregation of responsibilities in the zoning of disparate land uses, local administrative structures depend on disparate departments to manage the provision of basic services within individual urban sectors, accepting the belief that energy is not a municipal responsibility. However today, municipalities recognise the need to move away from the existing fossil fuel suffused model. Many have realised that this means changes to existing governance practices for the provision of local energy that is renewable and decentralised.

These changes are underway. By the end of 2012, there were 76 towns, cities, districts and regions in Germany classified as 100% renewable, with 60 areas currently moving towards the goal (IdE, 2013). Across the rest of the world, the number of villages, towns and regions that have similarly achieved the target or are moving towards the goal, total 27 and 25 respectively, with 10 countries having already established 100% renewable energy as a national objective (http://go100percent.org, http://ec.europa.eu/energy/idae_site/index.html).

This chapter is based on the principle that small municipalities can be purposeful and effective agents in the development of greater energy autonomy. With at least one-third of the German renewable energy regions having around 15000 inhabitants of less, being small have allowed those municipalities to pursue projects with ease and great independence (IdE, 2014). With obviously simpler administrative setups, these small municipalities have been able to adjust their governance frameworks, develop and deploy special-purpose external organisations, or simply use or modify their existing capacities more effectively and with a new purpose. They have even been effective in motivating the transformation of neighbouring villages and towns in the rest of the region. And yet, despite possessing these extraordinary powers of influence, municipalities throughout the rest of the world habitually use merely a fraction of this potential, especially in energy matters. Despite the availability of many public administrative tools at their disposal, local governments have been reluctant to mobilise themselves or undertake the necessary investments.

The 'Urban renewable power policy toolbox' outlines a range of tools that municipalities can employ to attain full direct energy independence (Droege et al., 2010). Based on practical case studies and expert knowledge, the toolbox was developed as a concise and simple guide for all villages, towns and cities to transform themselves into a 100% renewable community, no matter their size, society, economy or geographical context. However, the toolbox did not prioritise measures or discussed their degree of effectiveness. By using the toolbox as the basis of the Delphi expert survey in Chapter 3, the relative importance of each measure was tested. More detailed aspects related to the measures were also defined. These results were then synthesised as six critical factors for governing urban development for local energy autonomy.

The six factors developed based on expert opinion from Chapter 3 were:

1. Understanding the level of local government awareness of energy autonomy issues and capacities, including the reasons for positions held for or against energy autonomy that follows from a clear clarification of terms in the context of local community and government,
2. Appreciating and working with the influence of central government on local action in energy projects, with respect to regulations, legislation and standards in a planning, organisational and financial sense,
3. Seeking local government discretion to implement actions that directly pursue the goal of energy autonomy,
4. Analysing and utilising the existing local government structure, with augmentation to existing structures through public-private partnerships
5. Considering the role of the local leaders to motivate and to mobilise implementation - and
6. Creating a local energy potentials model by local government.

This chapter addresses the six factors in greater detail, and responds to Research Question 3, which was formulated in Chapter 1:

Research Question 3 In addressing the role of local government, what are the most significant urban development methods employed by authorities who have already achieved energy autonomy?

4.2 Approach

The municipalities of Wildpoldsried in Germany; Güssing in Austria and Samsø in Denmark were chosen as the case narratives in this chapter. They were chosen based on documentary evidence and practical demonstrations of their working as a 100% renewable energy community. The three municipalities were accepted as having achieved energy autonomy since they were able to meet their energy needs with their own supplies of direct – non-embodied or imported – RES for heating or electricity, excluding energy for transportation. This balancing of energy demand with supply is calculated on an annually basis in order to provide a more stable overview of the overall energy balance. The first time a town achieves a 100% energy balance is the point at which the community is classified as energy autonomous, even if this not achieved the following year, but does the year after. It must be noted that the energy balance can change from year to year depending on environmental, social and economic conditions, and thus it is not assumed here that 100% must be achieved in consecutive terms.

Each with fewer than 5,000 inhabitants, the three chosen municipalities have demonstrated the power of control, change and purposeful innovation. Through a comparative assessment approach, each of the energy autonomous municipalities were analysed against the six factors formulated through the Delphi survey. The factors suggested by the experts were compared with the measures actually implemented by the energy autonomous local governments. The most significant urban development methods employed were identified.

4.2.1 Wildpoldsried, Germany

Wildpoldsried is a small village municipality (population in 2012: 2500, village size: 21.4 km^2) in Oberallgäu (http://www.citypopulation.de), located in the southern agricultural region of the Free State of Bavaria in Germany. The municipality meets all of its electricity and heating requirements from local renewable resources based on wind power, small scale hydropower, and photovoltaic systems for electricity; and on biomass, biogas, solar thermal and geothermal energy for heating. By 2009, the village was exporting nearly three times its own electricity use as excess production into the power grid, realising healthy revenues thanks to Germany's renewable energy feed-in legislation. Seeking to go beyond renewable energy redemption, the village municipality advocates the use of 'ecological' materials for building construction and has established a natural water remediation facility as an integral part of its 'ecological energy plan'. Its energy strategy commenced in 1999.

4.2.2 Güssing, Austria

Güssing is a small town municipality in the Burgenland region of southeast Austria (population in 2013: 3700, town size: 49.3 km2, district size: 485.5 km^2) (http://www.citypopulation.de), located near the border with Hungary and Slovenia. It is the administrative centre of the Güssing district. Via an energy plan based on energy conservation, value creation and environmental protection, the town produces nearly all of its own fuel and energy for heating, electricity and transportation from local biomass. In operation are a district heating system, a biomass-gasification facility, several biomass co-generators, a rapeseed oil refinery, and a photovoltaic and solar thermal plant. Profits earned from its energy production services are reinvested in local renewable energy projects, creating new jobs and attracting companies to the town and surrounding region. The municipality also generates renewable power for industrial production. The town is part of the Eco-energy Land (Oekoenergieland) project of the larger Güssing district, which is also aiming towards energy autonomy. Güssing town is the veteran of our three cases, having officially changed direction in 1990.

4.2.3 Samsø, Denmark

Samsø is an independent island municipality located 15 kilometres off the Jutland Peninsula in Denmark (population in 2013: 3806, island size: 114 km^2) (http://www.citypopulation.de). In 1997, Samsø's 100% renewable energy plan was chosen as the winner of the Danish government's 'Renewable Energy Island' competition. Today, the island produces all of its electricity and almost all of its heat from entirely renewable sources of energy – 100% of its electricity needs from wind power, and 75% of its heating requirements from photovoltaics and biomass. It has achieved this via several land-based and offshore wind power plants and several biomass heating plants connected through a district heating network. Its success is largely attributed to a socially integrated energy development and planning framework that facilitates community shareholding in the island's many renewable energy plants (http://samsoe.dk). Its first community energy work groups were formed in late 1997.

Fig. 73. Location of the municipalities.

Table 3 summarises the key statistics of each local government.

Table 3. Case municipality statistics.

	Wildpoldsried, Germany	**Güssing, Austria**	**Samsø, Denmark**
Population	2500 people (in 2012)	3770 people (town) (in 2013) 26549 people (district) (in 2013)	3806 people (in 2013)
Population density	117 people/km²	77 people/km² (town) 55 people/km² (district)	33 people/km²
Area	21.35 km² (village)	49.3 km² (town) 485 km² (district)	112 km² (island)
Daily mean Jan & July temperatures	-0.5°C (min) 19.3°C (max)	-1.4°C (min) 19.6°C (max)	-0.4°C (min) 17.1°C (max)
Average sunshine hours	1725 h/a	2150 h/a	1800 h/a
Average wind speed	10 km/h	13 km/h	20 km/h
Land use			
- Agricultural	65.2%	46.5%	68.7%
- Forest	26%	42.4%	5.6%
- Settlement	8.3%	6%	15%
- Other	0.6%	5%	10.7%
Number of dwellings	649	1119	2846
Energy demand	5.6 GWh (electricity) 2.1 GWh (heating) 1.8 GWh (fuel)	50.2 GWh (electricity) 60 GWh (heating) 29 GWh (fuel)	153 GWh (electricity) 110 GWh (heating) 12.5 GWh (fuel)
Renewable energy generation	17.8 GWh (electricity) 5.4 GWh (heating)	22.2 GWh (electricity) 59 GWh (heating)	105.4 GWh (electricity) 19.3 GWh (heating)
Biomass district heating MWh/a= megawatt hour per year (number of households served, network range)	District heating (n=1) 2216.21 MWh/a (42, 2.6 km) Biomass (n=8) 285.13 MWh/a (heating)	District heating (n=11) Biomass Fernwärme Güssing – 50 MWh/a (400, 35 km) Fernwärme Glasing – 350 MWh (24, 1.6 km) Fernwärme Urbersdorf – 850 MWh (39, 2.5 km) Fernwärme Deutsch Tschantschendorf – 1200 MWh/a (41, 2.5 km) Fernwärme Kroatisch Tschantschendorf – 375 MWh (19, 0.65 km) Fernwärme St. Michael – 4000 MWh (110, 8 km) Bio-Fernwärme Eberau – 800 MWh/a (35, 3 km) Fernwärme Bildein – 1000 MWh/a (63, 2.7 km) Fernwärme Güttenbach – 5180 MWh (242, 6.4 km)	District heating (n=4) Tranebjerg 9500 MWh/a (263) Ballen-Brundby 3300 MWh/a (232) Onsbjerg 1500 MWh/a (76) Nordby-Marup 5000 MWh/a (178, 2500 m²)

	Wildpoldsried, Germany	Güssing, Austria	Samsø, Denmark
		Fernwärme Burgauberg – Not available (8. 0.25 km) Sonnensiedlung Stegersbach – 150 MWh (9, 0.45 km) Thermal gasification (n=1) 2 MWh electricity, 4.5 MW heating Methanisation (n=1) 8,4 GWh/a (heating)	
Biogas	Biogas (n=4) 5163.824 MWh/a (electricity) 2900 MWh/a (heating)	Biogas (n=1) Strem 4350 MWh/a (electricity - 1200 households) 5220 MWh/a (heating- 40 households)	na
Wind power	Wind (n=11 turbines) 12451 MWh/a	na	Wind (n=21 turbines) Brundby wind farm 12700 MWh/a (5 turbines) Permelille wind farm 7600 MWh/a (3 turbines) Tanderup wind farm 7600 MWh/a (3 turbines) Samsø offshore wind farm 77500 MWh/a (10 turbines)
Solar	Photovoltaics (n=210 sites) 4.69 MWh/a (electricity) Solar thermal (n=140 sites) 2100 m²	Photovoltaics (n=3 sites) 30 MWh/a	Photovoltaics (n=1 site) Energy Academy 8MWh/a
Water	Water power (n=3) 132 MWh/a	na	na
Geothermal	Geothermal (n=3 sites)	na	na
Investment in renewable energy	9 million € (5 million € credit, 4 million € equity – 180 local households, companies, municipality)	35 million € (13.5 million € district, national, EU; 2.734 million € municipality, 2.64 million € district, 2.64 million € local households, companies)	55 million € (8 million € national, EU, 47 million € local households, companies, municipality, energy company)

The following figures show the larger-scale renewable energy installations by area, with district heating shaded chronologically (latest projects shaded darkest).

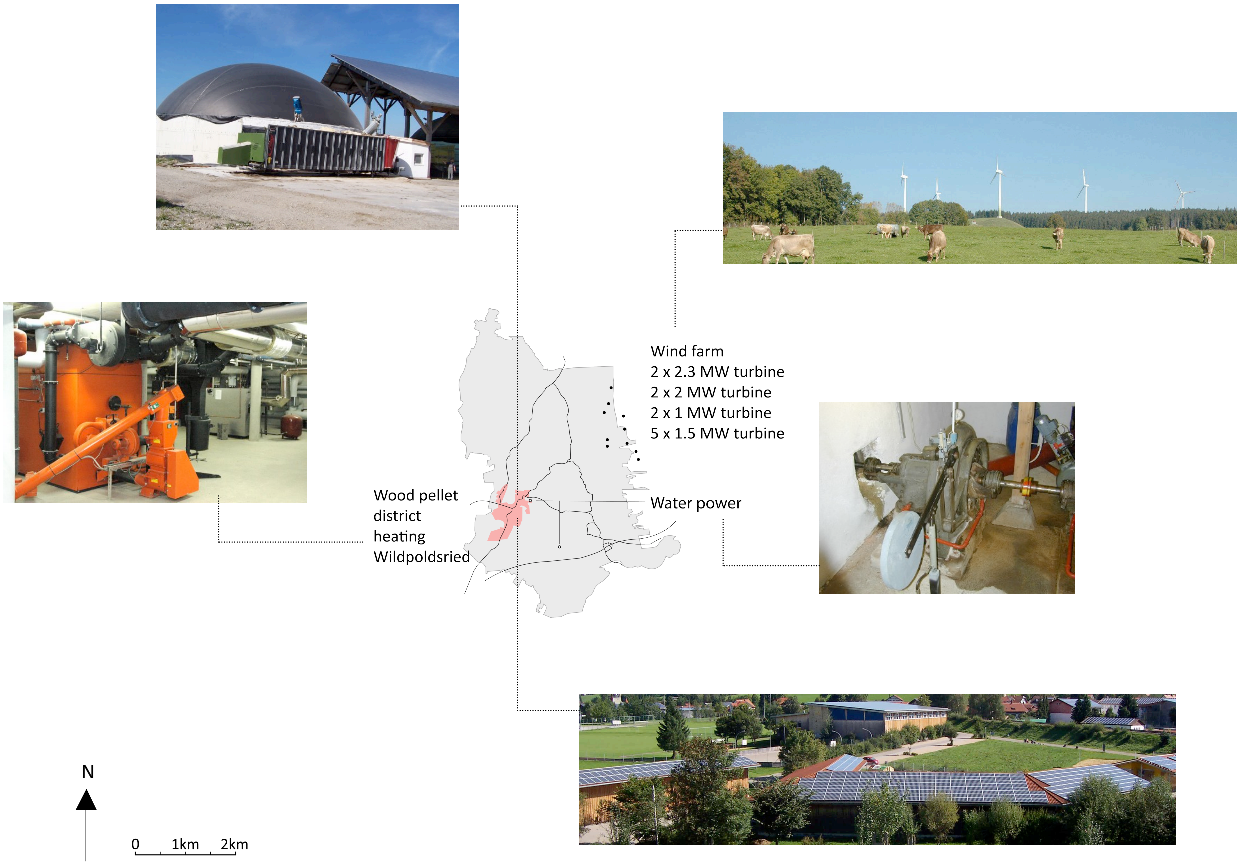


Fig. 74. Wildpoldsried, Germany (Own map, photos from http://www.wildpoldsried.de).

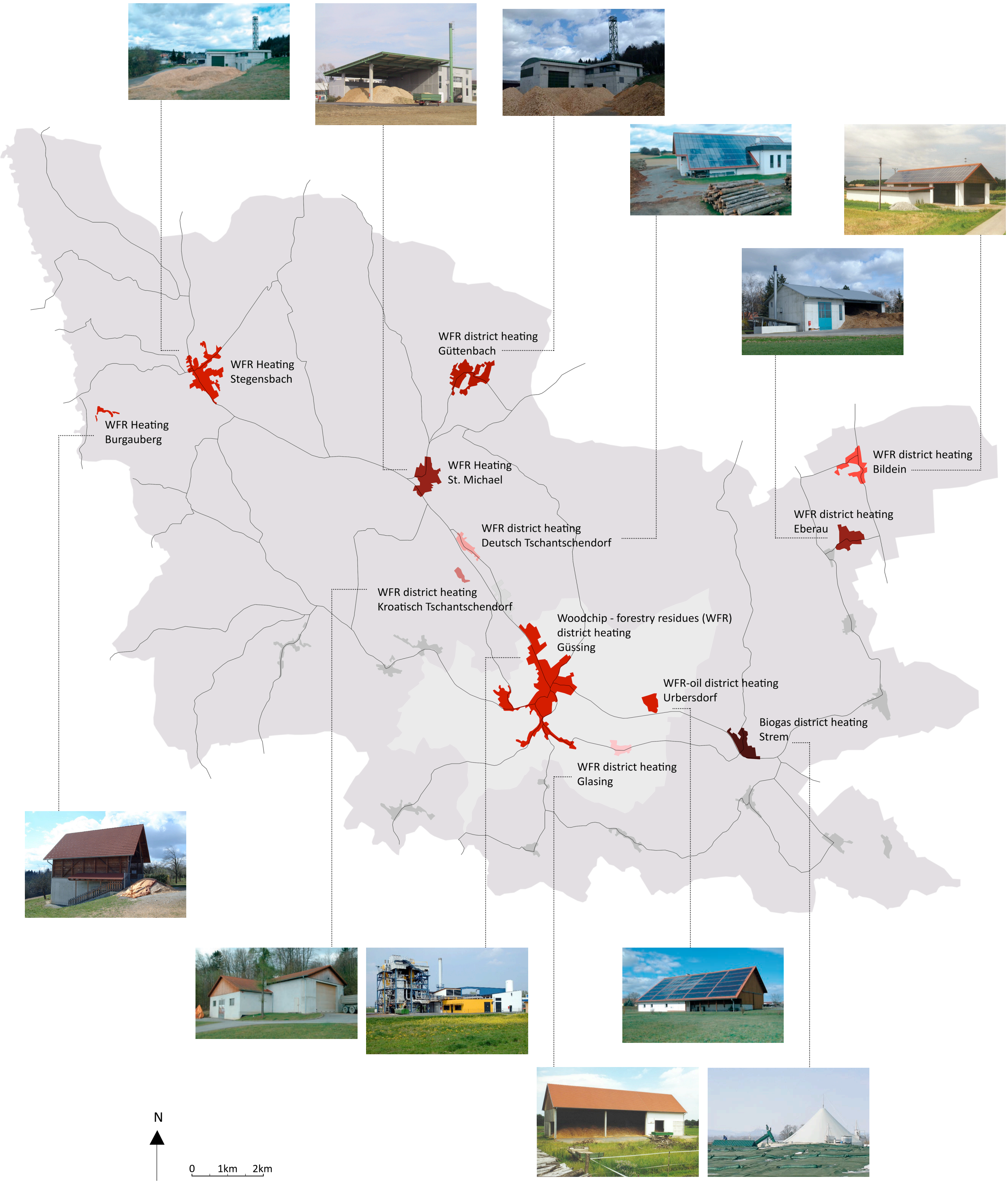


Fig. 75. Güssing, Austria (Own map, photos from http://www.eee-info.net).

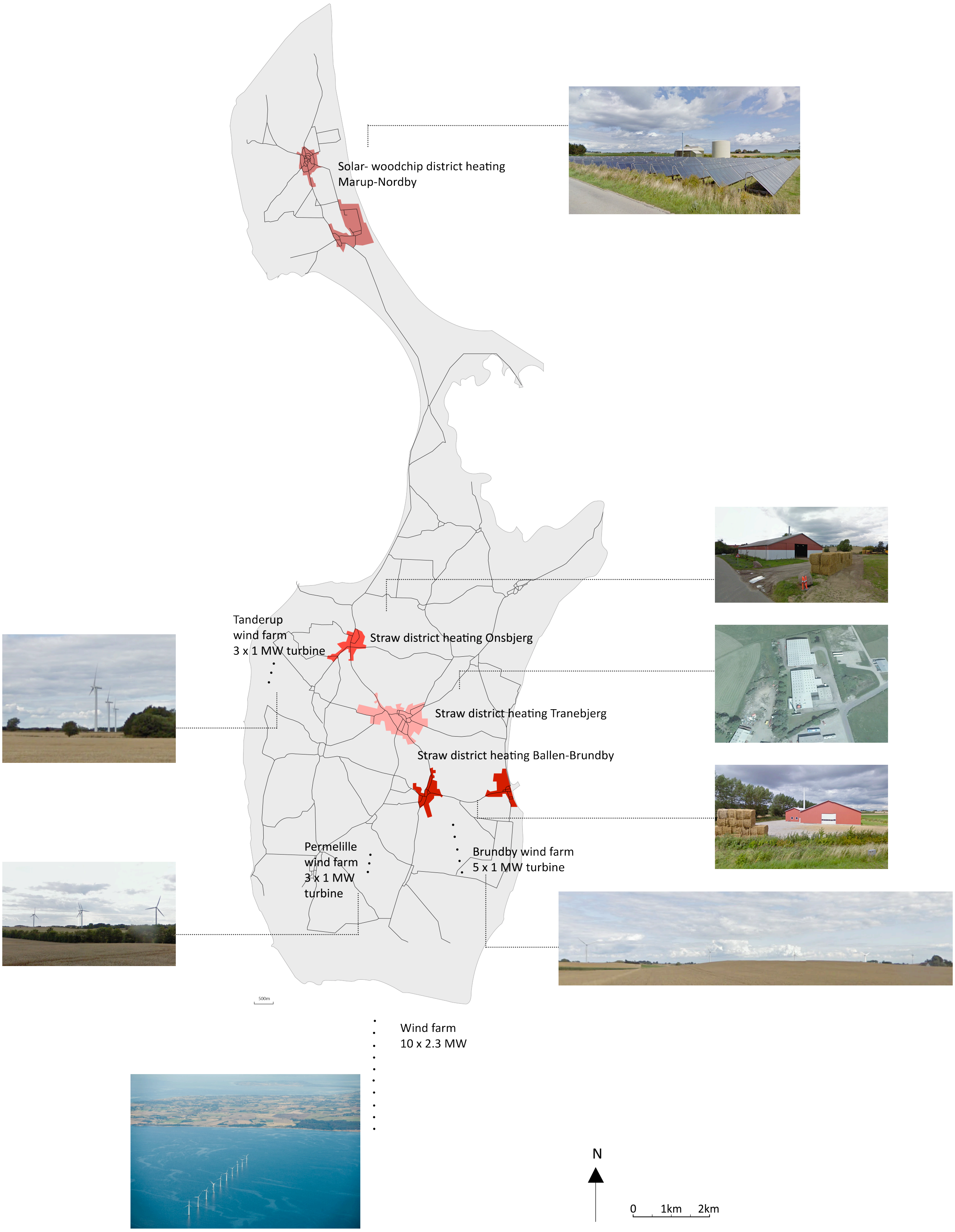


Fig. 76. Samsø, Denmark (Own map, photos from http://www.energiakademiet.dk, http://www.google earth).

4.3 Key factors for governing urban development for local energy autonomy

4.3.1 Factor 1: Local government awareness of energy autonomy issues and capacities

An awareness of energy and sustainable development by local government and its local community is essential for an aspiring or practicing energy-autonomous municipality. According to the experts in the Delphi survey from Chapter 3, if some knowledge of energy autonomy is not present, the ability of a local municipality to accept and embrace the concept diminishes considerably. In this section, I show that in the three cases, local government awareness of energy and energy autonomy was highly influenced by the backgrounds of councillors responsible for local energy, by local traditions and histories, by the manner in which local energy goals were conceptualised and translated into practical action, and by the awareness of the available opportunities to realise the goals.

Historical awareness of energy issues

Wildpoldsried

In Wildpoldsried, even before the local authority decided to create their energy plan in 1999, several renewable energy and environmental initiatives were already in existence. In 1992, local residents had developed and began running two small hydropower plants. There were small photovoltaic installations on the roofs of a few households. By 1994, a natural wastewater system had been built by the local landscape company in response to flooding issues, which had become a concern for residents. When the village's landfill closed, robust recycling programs were put into place. Residents with yards had to compost their gardening and food waste at home. These small actions, combined with global events, served as a huge influence on the local village government. More than a decade earlier, the Chernobyl nuclear disaster in 1986 had prompted talks between the local government and its citizens to think about alternatives to nuclear energy. Such experiences culminated in the genesis of the Wildpoldsried energy plan.

Indeed, the conception of the energy plan can largely be attributed to village mayor Arno Zengerle and local organic farmer Wendelin Einsiedler. Their backgrounds have served to influence a strong early awareness of, and support for climate protection and local sustainable energy generation.

The mayor had long been an advocate of renewable energy, and was the conceptual pioneer of the town's energy plan. Since 1966, a small twenty-five-kilowatt hydroelectric plant had supplied electricity to his home. As a member of the German political party CSU, he once asserted that: "sustainability and conservative values [being] inextricably linked" (Pahl, 2012). The Christian Social Union (Christlich-Soziale Union - CSU) is a party committed to free enterprise, federalism and a united Europe operating under Christian principles. With regards to energy and climate change, the party calls for increasing the share of RES, reducing emissions and ceasing the use of coal. The basis for implementation: an electricity capacity mandate for renewable energy producers, and accelerating investment in grid infrastructure, storage capacity and new technologies (http://www.dbresearch.com).

As municipal councillor, local organic farmer Wendelin Einsiedler was instrumental in developing and promoting the technical side of the energy plan. Today, he is intrinsic to the Wildpoldsried energy team, which is headed by the mayor, and has been famously nicknamed: the "wind pope" by the local community (Hooper, 2012). Einsiedler shares a position on energy and environmental protection similar that to his brother, Siggi Einsiedler, who also an organic farmer, are both adamant that the realisation of any energy plan for Wildpoldsried must combine ecological values. In an interview for Deutschewelle English news channel, (Siggi) Einsiedler remarked: "Twenty years ago I realised that this is the only way to do things. I'm a farmer who works with nature, and renewable energy means working with nature and not against it, so I was convinced. And I needed this conviction in order to convince others so it can develop and expand in Wildpoldsried" (DW English, 2011). Indeed, early awareness and conviction by actors who were already part of and integrated into the local community, and who were also willing to encourage their fellow neighbours to act were highly significant. In Mayor Zengerle's words: "Everything that happens anywhere depends on people, whether people get on with another or not, or whether or not there's resistance. We happen to have the good fortune that there are many influential people who have taken up this issue and are pushing it forward. A single individual doesn't stand a chance" (DW English, 2011). Indeed citizen support has not been lacking. According to mayor Zengerle "now the situation is such that everyone wants to contribute somehow" (DW English, 2011).

Fig. 77. Wendelin Einsiedler (left) with Mayor Arno Zengerle (http://www.br.de).

Besides the two main actors, several local residents were also part of the local government's energy team. These individuals not only brought into discussion, further community knowledge and aspirations, but they also brought in bipartisan confidence and a commitment to an ecological energy concept that was consistent with local Bavarian traditions.

This is an inherited, agrarian culture, which possesses a high degree of environmental consciousness and community commitment. It is an open-mindedness to embrace new concepts and to try new things, a consequence of high standards of education and wealth since the end of the Second World War (Karl, 2008). It is a history of self-determination and valuing of the common good. It is a product of the farming and the collective traditions that the Wildpoldsried community has inherited. These traditions could be traced back to the early agricultural and farming communities of the Middle Ages, whose basic principles were centred on the *Allmende* (Schlör, Fischer, & Hake, 2012).

In the 10th century, the traditional concept of the *Allmende* (commons or public ownership) was widespread in the countryside in many parts of Europe, particularly in the German Holy Roman Empire. Derived from "*all(e) gemeinde*" according to linguists, which means everybody who belongs to a community, the *Allemende* was the rule of the land. It stipulated that members of the community were permitted to use the resources of the local community provided they decide collectively on how the resources were used (Helfrich, 2011). The *Allemende* would designate the land, which is owned by a village or town and ensure that natural resources were not overexploited. "In this medieval legal system, the land did not belong to a person but a person to the land" (Schlör et al., 2012, p. 194). Indeed, land was vital for the supply of energy and raw materials to the village. A communal system of ownership and sharing of the land was essential for the benefit of the entire community, which meant that the system persisted for most part of the Middle Ages.

By the middle of the 14th century however, the accelerating use for timber for firewood from communal forests meant rapidly dwindling supplies, and villages soon recognized that the surrounding natural environment required stringent protection. In the meantime, local German feudalism also saw the need for environmental laws to protect the forests and to ensure timber resources for future generations. In 1568, the Duke Albrecht V of Bavaria remarked: "If we were not to intervene now, our subjects would face shortages of timber, which would cause irreparable damage to our country" (Köstler, 1934). Inevitably, such environmental laws also came to define the local power structure. By the 18th century, the word *nachhaltig* or sustainability in German had appeared within the context of forest management and future resource protection. But at the same time, the Hardenberg reforms had dismantled the medieval *Allmende* legal system, transferring the control over nature from the local community to the individual (Schlör et al., 2012). By this time, centralised, external control was required to manage the emergence of new fossil energy sources such as coal, which could no longer be efficiently managed through traditional collective endeavours.

Today, Wildpoldsried as an energy autonomous municipality exhibit qualities that hark back to the *Allemende*, reversing control over nature from the individual back to the local community.

Fig. 78. Farming life in the Middle Ages according to the *Allmende*. The village of Schöllbronn, 1485 (http://www.comeniuspro.net).

Fig. 79. Bare hillsides resulting from ruthless woodcutting around the Wilden See near Schönmünzach, Germany, historic engraving, 1800 (http://www.en.naturparkschwarzwald.de).

Güssing

The history of environmental (forest) protection echoes within the energy autonomous municipality of Güssing in Austria.

Prior to the conception of the Güssing energy plan in 1991, there were already several small initiatives operating in the town and surrounding region. Locals had been using wood, rapeseed and used cooking oil from the region for fuel for many years. Farmers had been using agricultural waste for biogas and biodiesel production for their own use in farm machinery. Foresters had been using forestry waste for their own heating purposes or for small localised heating networks. Some degree of energy self-sufficiency was achieved locally albeit at a very small scale. However, when town engineer Reinhard Koch conducted a study of the local council's energy and infrastructure expenditure in 1988, he found that over €6 million had been spent on imported energy. The municipality was facing a rise in local and regional unemployment, youth emigration, and a weakening transport infrastructure. At the community level, the use of imported energy continued unabated. Meanwhile, heating with petroleum was still considered modern and progressive (Sieberth, 2012). According to one former official from the European Centre for Renewable Energy (Europäisches Zentrum für Erneuerbare Energien - EEE), climate change or 'Peak Oil' or ecological was hardly a priority at the time.

It was at this point that local mayor Peter Vadasz decided that a dramatic change was needed to tackle their massive fuel debt and therefore address the remaining economic problems. It was reportedly the sight of vast acres of forests and agricultural fields from the top of Güssing Castle, which finally convinced him of the huge potential in local RES to directly address fuel debt, energy dependence, joblessness and infrastructure under-development (Douthwaite, 2006). Güssing's problems could only be tackled through the active replacement of imported fossil fuels with local RES to drive its local economy and in the long-run, contribute to larger sustainability goals.

With the help of Herbert Sattler, the head of the local timber growers' association, a municipal energy plan based on the generation of local renewable energy was conceived. Implementation by the municipality would mean using local resources to generate local income, creating jobs, controlling energy prices, and returning profits for future municipal projects. This idea of re-investing profits back into the locality was not new. Around twenty years earlier, savings and profits from municipal efficiency projects for drinking water and local sewage were returned to the community in form of new public infrastructure projects (Koch, 2008).

Indeed, the knowledge and expertise on resource issues within local government was already relatively high even before the Güssing energy plan was conceived. Local municipal engineer Reinhard Koch was initially employed by the municipality to plan Güssing's water and waste management system. Born in Güssing, Koch began as an electrical engineer who originally founded a planning agency in the 1980s focusing on industrial facilities and environmental techniques. Today, he is the Business Manager for the EEE in Güssing, which is co-owned by the municipality. With a combined knowledge in engineering and the environment, it allowed Koch to formulate a practical energy plan for the municipality.

Similarly, the mayor Peter Vadasz had long been a resident of Güssing. Before becoming mayor (1992-2012), he had trained and worked as a secondary school teacher. He was member of the Austrian political party ÖVP and also a member of the Burgenland Parliament (Landtag) (1996-2005). The Austrian People's Party (Österreichische Volkspartei - ÖVP) is a Christian democratic and conservative political party, which advocates economic liberalization, welfare reform and general deregulation. Over many years, the party has also adopted a more environmentalist stance compared to other similar conservative parties in Austria. The ÖVP is popular mainly amongst white-collar workers, large and small business owners, and farmers. One could argue that the mayor's high level of education and endorsement of private farming and forestry enterprises was instrumental in shaping the contents of the Güssing energy plan. His political allegiance was arguably influential in the initiation of the first few energy projects in Güssing. An example of this was the agreement to let the ÖVP, of which he was member, to take on the development of the local district heating network, rather than leave its implementation to the regional natural gas supplier BEGAS, which was dominated by the opposing Social Democratic Party (Sozialdemokratische Partei Österreichs - SPÖ) (Sieberth, 2012).

Fig. 80. Mayor Peter Vadasz (left) and DI Reinhard Koch (http://www.eee-info.net).

Besides the socio-economic difficulties experienced in the region, the mayor also recognised the enduring presence of the Burgenland Forest Association. With forest owners as its members, the Association had long been promoting the sustainable use of forests, formally so since 1976. Indeed, forestry waste was always recognised as an invaluable biomass source for heating in the region, and that its use for many had not been considered fully optimised: “In the past, the trees fell down, the wood was left to rot in the forest rather than being used” argued Herbert Stummer, Business Manager of the Burgenland Foresty Association (EEEGuessing, 2009). By strengthening its partnership with the Association, Güssing municipality was able to source ample supplies of timber and other forestry waste for its many energy plants. Today, the Association supplies around 35000 cubic metres of wood coming from a radius of around 25-30 km, which is about the size of the district of Güssing. It also continues to provide free advice in forest management and timber marketing.

There has always been a strong awareness in Güssing for the sustainable use of natural resources, especially for a region, which has long been dominated by forests – in 2012, it covered around 43% of the district. If we were to trace back to the early Middle Ages, Alpine forests in Austria were, like in Germany, also managed as a commons and were regulated by the local communities. Portions of forests were converted into farmland, making way for pig, sheep, goat or cattle grazing, and for producing fuel wood and timber – a system of multiple-use, which constituted a form of sustainable land management (Schlör et al., 2012). However the local extraction of biomass from forests over time did eventually lead to the degradation of sites, which then warranted the preservation of sections of forests. It also led to conservation laws such as the Forest Ban (Waldbann), which prevented the exploitation of forests on sloping ground in order to protect settlements against avalanches, mudslides and rock-falls.

Another pressure on local forests was the rise of the new territorial sovereignty in Austria. A system was by then in place to allow the national sovereign to claim back all of the forests and redistribute them amongst its aristocrats. The objective was no longer about supplying fuel and food to the population but to maintain existing hunting grounds and the supply of wood to support the workings of the newly developed salt and ore mines, owned by the aristocrats. However by the mid 19th century, timber resources to support such industries were hugely depleted. Revolts against the sovereign ensued as the local communities wanted to defend their rights to use and preserve the forests. Eventually, the Austrian sovereign was forced to establish similar forest laws to those in Germany. With the revolution of 1848, the privileges of the aristocrats had been abolished. The private farm and forest ownership with full civil and property rights were established and the State's role in forest management was limited to the administration of forest law. The Forest Act of 1852 would preserve all forestland but it also obliged all forest owners to manage their forests according to the principles of “sustainable forestry.” Today, these principles are still the basis for practice for Austrian foresters (Pregernig & Weiss, 1998). Within the context of forestry traditions in which Güssing has been shaped, the town has carried with it over time an approach that seeks to maintain this sustainable use of local resources for the benefit of the entire community.

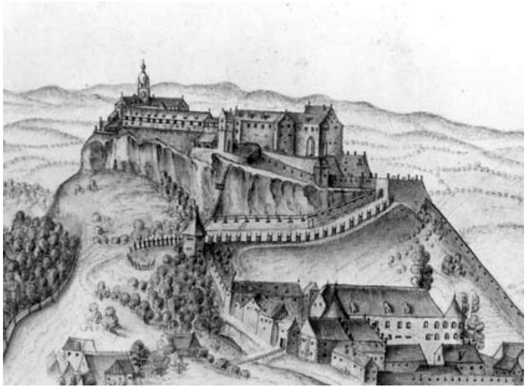


Fig. 81. Güssing Castle is a remnant of the Austrian feudal system, the structure of which still exists today, pen drawing by Johann Ledentu, 1639 (http://www.guessing.co.at).

Fig. 82. Continuing tree felling practices in the late 19th century Austria (http://www.lebensministerium.at).

Samsø

Exploiting existing community consciousness and collective traditions have also helped the island of Samsø in Denmark to achieve its own energy autonomy goals.

Several traditional water and windmills had been in existence on the island since the 1600s, and it was not until the 20th century when large-scale installations were put into place. These larger projects began with the establishment of the small wind turbine shareholder association “Samsø Wind Energy” in 1983. Pioneered by Denmark’s National Wind Turbine Association, it gave local residents the opportunity to invest in the local windpower projects. By the time Samsø’s seminal ‘Renewable Energy Island’ plan was conceived in 1997, there were already several development applications for the installation of wind turbines (n=17) on the island.

Another pioneering project was the development of the island’s first large-scale straw-fired heating station and district heating network, which was opened in 1994. Based on earlier attempts to create a district heating scheme using a large oil boiler and a heat pipe system, these early systems had failed due to large heat losses. However, because a few local residents were still convinced that a modern district heating system was still possible due to the abundant supply of straw on the island, the latest project was lobbied for with the help of local power company ARKE (now NRGi). Together with the local citizens´ group, they convinced most of the community that district heating was a viable alternative to individual electric heaters and oil boilers. By 1997, over 80% of the island's population were connected to this heating network.

Meanwhile, the local energy company ARKE had begun campaigning for the replacement of electric heating and oil heating with solar and heat pumps, which succeeded in attracting 50 households. The local school had also installed its own wind turbine.

Despite these efforts, renewable energy at the time still constituted only 13% of the island's energy supply. Samsø remained heavily reliant on fossil fuels that were transported to the island by tankers, and was completely dependent on electricity via under-water connections to the mainland grid. The local economy was also very weak due to the decline of its agriculture industry over many years, culminating in the shut down of its local slaughterhouse. To save on costs from imported energy, some island residents resorted to developing their own energy savings measures. Local farmers began developing different cultivation practices and improving driving techniques and engine efficiency in order to decrease the demand for diesel. Local residents began installing their own photovoltaic panels or heat pumps, but begun to query whether this was really enough to counter the still growing dependence on imported oil and electricity.

Like in Wildpoldsried and Güssing, the impetus to establish an energy strategy, in the case of Samsø - for submission to the Danish Renewable Energy Island competition in 1997, can be accredited to two major figures - Bent Schaloffsky, an engineer from Århus County who worked in Samsø, and the then-mayor John Sander Petersen (1994-2002). Schaloffsky had read about the competition for the Danish 'Renewable Energy Island' and had approached Petersen to take up this opportunity. The competition was to develop a comprehensive energy plan that could achieve the target of 100% energy self-sufficiency within 10 years with only local resources. Petersen was interested because of the business opportunities it would offer Samsø. They consulted PlanEnergi and utility company ARKE to prepare their energy plans, and continued developing the plan by collaborating with the rest of the municipality, including Samsø Farmers' Association, Samsø Business Council and several community representatives chosen by the newly created Samsø Energy and Environment Office (SEEO).

A special energy team was created by the local government to implement the energy plan, which included its original supporters, engineer Schaloffsky and mayor Petersen. Another significant member was Søren Hermansen, a local energy advisor and environmental teacher. Experienced in rallying community participation, many have attributed Hermansen's involvement as one of the main reasons behind Samsø 's success in reaching the 100 percent target. He had not only brought local opinion leaders and citizens together and convince them of the energy plan, but also encouraged them to participate in, and in the long-term, even run the implementation process. Meanwhile as President of the Business Council, Bent Schaloffsky ensured political and commercial support for the project. His initiative to raise awareness amongst the municipal council regarding the Renewable Energy Competition can be attributed to his background as local engineer and knowledge of the resource potentials on the island. And as a member of the Danish political party Venstre (V), mayor John Sander Petersen, was instrumental in maintaining cross-party support for the 100% vision, and lobbying within the context of his conservative-liberal party. The Venstre political party is founded on the Nordic agrarian tradition, which supports free market thinking. Its energy policy strongly advocates reducing carbon emissions and promoting Denmark's independence from the use of coal, oil and gas, achievable through increasing funding for renewable energy, building new installations, saving energy and increasing efficiency. It is interesting to note that like the farming revolts in Germany and Austria, the Venstre political party also shares similar roots in the peasants' movement against the landed aristocracy (Marano, 2009/2010).

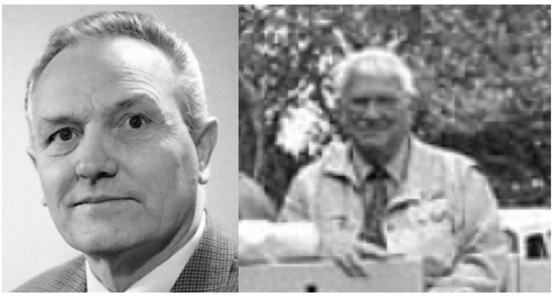


Fig. 83. Mayor John Sander Petersen (left) and Bent Schaloffsky (http://www.danskekommuner.dk, http://www.evolution.skf.com).

It is important to note that the main promoters of the Samsø energy plan were all from the island and were completely integrated into the community. The expression of strong cultural links to and within the energy plan was essential.

Indeed, the cultural environment in which the Samsø energy plan was conceived had long been shaped by the island's geography and Denmark's long-standing tradition of community ownership and civic engagement. As an isolated island, its society has always been left to consider ways of managing themselves. As for the cooperative tradition, this can be traced back to the Danish cooperative movement *Andelsbevægelsen*, which saw the establishment across Denmark, the cooperative dairies in 1882, the agricultural fodder association in 1883, the slaughterhouse cooperative in 1887, and the banking cooperatives in 1914. The cooperative system had become "the way of organizing all common practical matters among the Danish rural population" (Chloupkova, Svendsen & Svendsen, 2003, p. 243). The *Andelsbevægelsen* originally emerged from the peasant political movement focused around the farmers' party (Venstre) and the rural cultural movements, such as the free church, free school, and folk high school movements (Marano, 2009/2010). Its principles laid the foundation of a community entrepreneurship model, which manifested in the first Danish cooperative dairy. The model exemplified efficiency and democracy and had evolved from the late 19th century as a form of self-organisation amongst dairy farmers where the profits were shared, the price of milk was controlled, purchases and distribution were ensured, animal welfare was protected and milking practices were improved. As a cooperative, the farmers were able to share the risks associated with economic downturns, and be assured of certain economic guarantees. Compared to just one in 1882, the number of cooperative dairies in Denmark rose to 700 by 1890 (Marano, 2009/2010).

It is thus unsurprising that the cooperative form of energy planning and ownership proposed in the Samsø energy plan were comfortably accepted by the citizens of Samsø, since they were, one could argue, innately familiar with such ways of organisation. It may have also been in the psyche of policymakers prior to the plan's conception.

Fig. 84. Folk high schools were originally founded to bring non-formal education to the peasant population so that they could also actively participate in the modern Danish state. Teaching at Askov folk high school, painting from 1904 (http://www.pub.uvm.dk).

Fig. 85. The first cooperative dairy in Denmark, Hjedding Cooperative Dairy was established in 1882 (http://www.pub.uvm.dk).

Energy autonomy as an explicit goal

Was energy autonomy even part of the lexicon of any of the three energy plans, and if it did to what degree did it influence local policymakers?

Wildpoldsried

In Wildpoldsried, energy autonomy was never an explicit goal. The pursuit of an exact numerical energy target was absent. Instead, their 1999 plan focused on just three basic themes: energy savings and renewable energy production; sustainable construction of buildings by using ecological building materials such as wood; and water resource protection through the ecological disposal of wastewater. The themes resided under the slogan “Wildpoldsried Innovative Leadership” (Wildpoldsried Innovative Richtungsweisend – WIR). The broad guidelines aimed to inspire local citizens to do their part for the environment, encourage local innovation, and create green jobs and businesses for the community and surrounding areas. As described earlier, these themes were directly related to the circumstances, issues and events the village had experienced in earlier years. These referred to the continuing trend for installing renewable energy technologies by local households, using local timber for building construction, and addressing the problem of local flooding. Energy autonomy was never the original intention, nor was the eventual outcome in 100% energy self-sufficiency formally predicted or expected. Instead the focus was on small, basic goals that targeted known local issues. This meant that local actions were swift since it responded to matters of local urgency. One could argue that it may have required much explanation and translation to the wider community if energy autonomy was the stipulated policy target, acting to consequently stagnate or slow down the implementation process. In Wildpoldsried, the focus on small local energy and environmental projects, which could be 'built upon' over time – either expanded or used to open up new prospects, have avoided such conceptual contentions.

Güssing

In Güssing, although energy autonomy was also never specifically articulated, several presentations on energy by the municipality since the conception of its 1991 plan have stated the aim of "gaining independence from fossil energy in order to strengthen regional added value" (Schabhuettle, 2011; Keglovits, 2012). One could argue that "gaining independence from fossil energy" also means being free from fossil fuel use and being able to take control over one's energy supplies by replacing incumbent energy sources with local (renewable) energy. With the motto "Cyclical Satisfaction of Need" (Kreislauforienteierte Bedarfsdeckung), its energy plan also alludes to the pursuit of self-sufficiency in energy, showing that the acceptance of energy autonomy in the Güssing energy plan has been inherently implicit. This sits in contrast with the clearly articulated aims to: increase local employment opportunities, prevent youth emigration and decrease municipal energy debts, by implementing decentralized local energy production based on local renewable resources.

Samsø

Like the two earlier cases, the words *energy autonomy* did not figure at all in Samsø's energy plan. But unlike the two previous communities, the words 100% self-sufficiency was explicitly defined (PlanEnergi, 1997). Dictated by the original brief of the Danish 'Renewable Energy Island' competition developed by the Danish Energy Agency, the island had to basically demonstrate that it could become 100% self-sufficient in heating and electricity based on local renewable energy resources all within 10 years. Samsø's strategy was five-fold. First, cut consumption and increase efficiency in heating, electricity and transport by adjusting people´s behaviour and by using the latest energy technologies. Second, expand the district heating supply systems and combine with the utilisation of local biomass resources. Third, expand individual heating systems using heat pumps, solar heating, biomass-plants and other means. Fourth, construct land-based and offshore wind power plants to cover electricity production. And fifth, gradually convert the transport sector from petrol and oil power to electrical power, and later to hydrogen (Instituto para la Diversificacion y Ahorro de la Energía [IDEA], 2001). It is interesting to note that the first three recommendations of the Samsø energy plan also featured in the energy plans of Wildpoldsried and Güssing. In Samsø, an energy plan based on a target of *100% renewable energy* rather than on a vision of energy autonomy, served to better focus minds on ultimate yields.

Awareness of funding opportunities

Following an awareness of energy autonomy or 100% self-sufficiency is an awareness of the available instruments that could transform the vision into a reality. State, regional or international level incentives lay at the heart of all three local energy plans, particularly the national feed-in tariffs. In this section, I show that the early pioneers were aware of the available incentives and funding opportunities for local energy generation before the energy plans were conceived. There was also awareness (or assumption) that following success, new opportunities would arise. It is interesting to note that in all cases, the municipalities were most likely to be informed of further opportunities through external parties rather than through their own research efforts.

Wildpoldsried

In Wildpoldsried, mayor Arno Zengerle was aware from the early stages, of the opportunities and incentives for generating local renewable energy. Sustainable energy policy was high on his agenda (DW English, 2011) and he knew that the Bavarian State government could provide the necessary support. The Free State of Bavaria had been supporting the installation of biomass heating and combined heat and power plants, through direct investment subsidies since 1990. In 1991, Germany had adopted the power feed-in law (Stromeinspeisergesetz). In 1995, the city of Munich became the first Bavarian municipality to adopt Local Agenda 21. And by 1997, Bavaria was the first state to adopt the overall Agenda 21 strategy. The State passed the 'Bavaria Agenda' (Bayern Agenda) followed by the 'Action for a Sustainable Bavaria' (Aktion nachhaltiges Bayern). It also created the agenda transfer institution 'Agenda 21 Headquarters for Bavarian Municipalities' (KommA21 Bayern) in that same year, embedded in the Bavarian Environmental Protection Agency (Bayerisches Landesamt für Umweltschutz). This arrangement ensured that *KommA21 Bayern* was accepted both by the state government (Landesregierung) and by local authority administrations and mayors of Bavarian towns and cities (Kern, Koll, & Schophaus, 2007). The agency would facilitate the exchange of experience and transfer of best practice between the cities. In financial terms, the Bavarian government also supported the LA21 processes through its 'General Environmental Fund' (Allgemeiner Umwelftfonds). Through resources provided by the EU's structural funds, local authorities could also receive financial support for model projects, process management, agenda competitions and awards. In 2000, the new renewable energy law (Erneuerbare-Energie-Gesetz - EEG) superseded the earlier power feed-in law thereby driving Wildpoldsried's path to self-sufficiency in electricity, which was achieved two years later.

Güssing

In Güssing, mayor Peter Vadasz was quick to recognise the associated benefits entailed in Austria's accession to the EU in 1995. He was also aware of the available funding opportunities provided by the Austrian national government as well as the Burgenland provincial government. First of all, Burgenland's designation as an Objective 1 region meant that the region was entitled to funding for special development projects from the EU, through the European Regional Development Fund (ERDF) and the Social Cohesion Fund (SCF). Objective 1 support from the ERDF was ideal to provide the missing funding for projects for remote heating from biomass at the local level, through the use of residues from agriculture, forestry and timber processing (EU, 2009). From the national side, financing opportunities were also available through the Austrian Research Promotion Agency (Österreichische Forschungsförderungsgesellschaft - FFG). The adopted strategy of combining funds was essentially the basis of implementing projects in Güssing, enabling the local authority to seek partners, obtain access and learn about certain technologies and set up several demonstration facilities. As described earlier, the presence of the Burgenland Regional Forest Association also facilitated the development of projects associated with sustainable forest management. It took another year after Güssing had reached 100% self-sufficiency in electricity (and 80% in heating) in 2002, before Austria formally enacted feed-in tariffs for biomass, biogas, geothermal, solar photovoltaics and wind energy.

Samsø

In Samsø, the local authority was conscious of the economic, social and environmental benefits of generating local renewable energy. They were also aware that first and foremost, national government assistance would be limited from the beginning. In fact, the 'Renewable Energy Island' competition brief specifically stipulated that the winning plan should expect limited subsidies or tax breaks from the central government. As a consequence, the local authority realised that the mobilisation, finance, construction and operation of the various projects required, would call for urgent local stakeholder participation. A close review of the original 1997 submission showed that it was essential that specific actors were engaged in the process: the local energy company ARKE, the Samsø Farmers Association, the Samsø Business Association and local residents (PlanEnergi, 1997). In relation to project financing, the local authority was also aware of the possibilities provided at the regional, national and transnational levels of government (EU). Via the Århus County Office at the regional level, for example, it was able to apply for EU funds (Leader 2 and Objective 5b) even if it had not yet been formally reserved by Århus County. Via the national energy laws, the local authority was able to take advantage of price premiums for onshore and offshore windpower (in place since 1991), subsidies for district and household heating systems, and grants for wind turbine upgrades. Via the Danish Energy Agency, it was able to apply for assistance for areas designated by the municipality as a special district development area (egn udviklingsområde) and employ national Energy Officers for the island. The local authority was also able to make use of the Urban Renewable Village scheme run by the Danish Housing Agency. However it took another five years after Samsø reached self-sufficiency in electricity in 2003, when the Danish Renewable Energy Act was finally enacted to include feed-in tariffs for biomass, biogas, solar photovoltaic and wave energy.

4.3.2 Factor 2: The role of the national government

Regional or national governments can provide legislation and standards where municipal discretion to regulate is limited. With upper-level backing, local municipalities can strengthen and enforce building efficiency standards and mandatory renewable energy provisions for new buildings and renovations. They can even make renewable energy self-sufficiency mandatory through climate, resource, and pricing support mechanisms. In this section, I show the level of influence of the central government in the building and planning frameworks of each case.

Wildpoldsried

In Wildpoldsried, local building and planning regulations were not wholly dictated by the national government. Centralised influence came in form of special standards in building construction (Passivhaus), guidelines for preparing landuse plans for sustainable development (Building Lawbook [BauGB], 1997), and rules defining the national feed-in tariff. Instead, Wildpoldsried's building and spatial rules were largely guided by the Free State of Bavaria – via the Bavarian Building Regulation (Bayerische Bauordnung – BayBO). The provisions worked together to regulate electricity and heat consumption as well as manage local renewable energy supply and technology installation. The State Ministry for Environment and Health (StMUGV) also encouraged the Wildpoldsried's participation in the European Energy Award® (eea®), which had motivated the village to pursue advanced measures in spatial planning and public buildings, alongside measures related to services supply, waste management, mobility, internal organization, communication and cooperation. The locality's energy strategy is audited every four years to maintain accreditation to this award.

Bavarian rules played an important role in easing permitting processes in Wildpoldsried and in the rest of the state, way before Wildpoldsried had achieved energy autonomy. Since 1997, the installation of energy generating facilities such as combustion equipment with a heating capacity of up to 50 kW for new and over 50 kW for upgraded systems; heat pumps; solar photovoltaics and thermal systems in the roof area, on facades, or on flat roofs up to an area of 9 m^2 were all permissible and did not require planning permission (BayBO, 1997). This was followed 10 years later to also include stand-alone solar installations that were constructed independent of the buildings with a height up to 3 metres and a total length up to 9 metres; small wind turbines with a height up to 10 metres; and small cogeneration units (BayBO, 2007).

In recent times, BayBO was revised to also recommend changes to local land-use planning. By 2011, the Bavarian government had begun advising local authorities to designate special areas for renewable energy production in their local zoning plan and development plan, from for example, ground-mounted photovoltaic systems and biomass plants (Bayerisches Staatsministerium des Innern, 2011). The zoning of renewable energy technologies would enable their implementation without planning permission. The intention was to make the municipal land-use plan more comprehensible and relevant to potential investors in renewable energy. It would also avoid 'preventative' attitudes in planning – such as stipulating where and what types of facilities *cannot* be installed. Interestingly, Wildpoldsried already had a land-use plan for the construction of wind turbines by 2008, three years prior to the RES zoning recommendation by the Bavarian government.

It is important to note that no special local building or spatial planning rules were specifically devised in order to implement the original energy plan. Instead, Wildpoldsried first targeted energy consumption, heating efficiencies and the use of renewable electricity in all of its municipal buildings.

Based on Bavarian codes, energy performance certificates were required for the renovation of all old municipal buildings and the construction of new buildings. Varied according to the type of building, the German national building standard (DIN V 18599 - Energy performance of buildings standard) formed the basis of this certificate.

It was 2011 when Wildpoldsried decided to adopt the national ordinance requiring all new home construction to incorporate energy efficiency measures, and be in line with the national Passive House (Passivhaus) program, a scheme, which began in the early 1990s. The municipality also began providing a municipal rebate for new home construction, which helped to offset the cost of building a 'zero energy' home. With the rebate, new homeowners were entitled to 15 Euro/m^2 toward the cost of the land if they constructed this type of house. The municipality also contributed half of the cost of the thermal scanning of homes in the community, which was used to identify energy and heat losses and thereby determining the degree of renovation required. On the basis of the results, the homeowner can undertake the necessary energetic improvements during building remodelling, with new windows, insulation improvements, and replacement of oil heaters with biomass heating, solar thermal or geothermal systems. Although the national Passive House program, municipal rebate or thermal scanning did not have great impact on Wildpoldsried becoming energy autonomous - the village having already achieved the target in 2002 – it did provide the basis for encouraging more sustainable construction on a voluntary basis and prompt small amendments to local building codes. Today, the local building code specifically regulates the orientation of new buildings to optimise solar gain by at least 15 degrees, with recommended angles for roof pitches of between 26 and 32 degrees. In comparison, Bavarian state rules are not as specific.

The Wildpoldsried energy plan focuses on timber as the most ecological material for building construction. This is in line with the forestry policy endorsed by the Bavarian government. And to ensure that the raw material for authentic renewable energy production is sourced locally, Wildpoldsried maintains the sole use of wood pellets produced from waste wood sourced from the regional wood industry. The local authority's ecological wastewater treatment, essential to the overall WIR energy plan, was also guided by the Bavarian guidelines for water remediation, with Kempten Water Authority and the Office of Oberrallgäu Health Department being instrumental in the certification of its water treatment facility.

Güssing

In Güssing, local building and land-use planning regulations were at the time largely defined by the regional government (Landesregierung) – in this case, the provincial government of Burgenland. National level influence was in the form of the voluntary Passive House standard, whose promotion began in 1998. Regional level influence was in the shape of regional energy efficiency laws, which encouraged the renovation of public buildings and the retrofitting of residential buildings to conserve energy in the rest of the municipality. Energy performance certificates were a general requirement, like in Wildpoldsried, though with some exemptions depending on the function, size or age of the building (Burgenland Building Regulation [BauG], 1997). Certificates for example were unnecessary for temporary buildings, residential buildlings used less than three months of the year, industrial buildings, religious buildings and historical buildings. Vendors and landlords were required to provide energy certificates for buildings when they were sold or rented. At the time, rules governing energy also mainly stipulated energy efficiency requirements for heating, with fuels still centred on heating oil or gas (Burgenland Building Ordinance [BauVO], 1998). Efficiency was prioritised in the Burgenland Housing Subsidies Act of 2000, which aimed to save 10% of the energy consumption of households by replacing old with new buildings, introduce mileage awards, and energy savings promotion. As for the integration of renewable energy technologies in new and existing buildings, these were generally guided by Burgenland's building and energy policies, via the Burgenland Energy Agency (Burgenland Energieagentur) (http://www.eabgld.at).

The degree of influence of the province was largely underscored by the regional project South Burgenland Energy Cluster (Energy Cluster Südburgenland), which had chosen and designated Güssing as one of four locations in the region to become pilot energy towns. The project's aim was to develop the energy technology sector within each town and transform them into an energy technology hub, thereby creating within them platforms for information sharing and promotion, and regional economic cooperation. This project served as an important catalyst to the development of projects within the larger district of Güssing.

Meanwhile at the local level, the municipality of Güssing wholly managed the planning processes, which handled the large-scale renewable energy installations. The local authority's primary task was to retrofit all municipal buildings, manage building permits, zone for demonstration facilities, and enforce environmental protection through environmental impact assessments. The local authority also provided favourable leasing arrangements for renewable energy companies who wished to set up premises in the municipality. Spatial planning laws of the province did not stipulate any requirements with regards to energy efficiency or renewable energy, except for requiring good infrastructure for local energy supply networks (Burgenländisches Raumplanungsgesetz, 1969).

It took several years after Güssing had reached its 100% target in electricity in 2001 when several national laws pertaining to RES were finally enacted. These included the Green Energy Act (Oekostromgesetz) in 2002, the Energy Certification Provisions Act (Energieausweisvorlagegesetz - EAVG) in 2006, the Combined Heat and Power Act (kWk Gesetze) in 2009 and the Housing Subsidy scheme heating standards also in 2009. The national government also established the target of 34% target and 10% biofuels use by 2020. At this point, electricity from RES was formally promoted through a feed-in tariff and given a secure priority access to the grid. Biofuels would for example be exempt from fossil fuel taxes. The Burgenland Energy Concept of 2003 (Burgenländisches Energiekonzept 2003) (Bürgenlandische Energie Agentur [BEA], 2003) had begun introducing new subsidy frameworks for renewable energy projects. Provincial funds could now contribute up to 30% of the cost of technologies such as heat pumps, water pumps, solar thermal systems, household central heating systems with biomass, and connections to biomass-powered district heating networks. (In later years, the province also began providing additional grants for single-family houses that achieved the *Passivhaus* standard). There were also guidelines for the promotion of businesses in the fields of the environment, ecology and energy.

When the Austrian 'Climate Active' (klima:activ) initiative was established in 2004, building owners were given further subsidised access to individual counselling and quality assurance for the construction of properties from residential homes to commercial buildings. This was followed by the development of a revised building code (Baustandard), which aided the assessment of building quality in relation to design, energy, construction, comfort and indoor air quality. In that year, legislative revisions also began stipulating that local authorities should set an example for reducing the carbon emissions in the building sector by managing the energy efficiency and wide use of renewable energy resources in public buildings, as per the national constitution (Article 15a, B-VG Agreement) (Lebensministerium, 2004). Minimum heating requirements for the construction and renovation of public buildings were outlined but only in terms of energy efficiency standards. The use of renewable energy sources remained subject to laws of the state provinces.

Samsø

In Samsø, initial national government influence was via the Danish Energy Agency, which was responsible for drafting the original Renewable Energy Island competition brief. Based on recommendations of the national government's Energy 21 Plan of 1997, the concern of the brief was to achieve the national target of 35% of gross energy being supplied renewably by the year 2030 for the whole of Denmark. Following the energy plan, the agency was instrumental in issuing grants, promoting various national schemes, and revising energy legislation. For example there were grants for district heating systems and individual heating systems throughout Denmark, which continued until 2002. Since 1983, the agency had driven the national government's renewable energy ownership scheme, which made possible the public ownership of shares in energy projects. Windpower implementation was significantly boosted by 1991, when onshore and offshore windpower projects began benefiting from a national price premium of around 3.6 cents/kWh, which was in place until 2001. The price of windpower paid to consumers was 85% of the local retail price of electricity excluding taxes. The premiums grew to 8 cents by the time Samsø's plan was put into action. There was support for replacing old turbines with new ones, a scheme, which subsequently ended in 2003. The liberalisation of the Danish electricity market in 1999 also meant that renewable electricity was to be paid by all electricity consumers as a public service obligation (PSO).

In terms of operationalisation, direct national government involvement was limited to basic grants, legislation and advisory measures. On Samsø, direct advisory assistance was in the form of one Energy Service Officer provided via Energy Service Denmark. This individual assisted in the dissemination of information related to energy savings and renewable energy to the general public, schools, businesses, and tradespeople.

When Samsø first achieved energy autonomy in electricity in 2003, it had achieved this primarily through windpower. Like any other infrastructure, wind turbines in Samsø at the time underwent the traditional planning process of complying with municipal and local plans, conducting environmental impact assessments, and attaining the required building permits. Municipal planning work for windpower in particular, was at the time, legally guided by the Danish Ministry of Environment via its 1999 Circular on Planning and Rural Zone Permits for Wind Turbines. The document stipulated general requirements regarding the siting of turbines in areas dedicated in municipal plans, specifications on the design and construction of wind turbines, and the minimum distance between a turbine and its nearest neighbour. For example, turbines should preferably be placed in groups, keeping a distance to neighbour buildings of at least 4 times the total turbine height and 4.5 kilometres to other existing or planned turbines. The maximum height of wind turbines would be set to 150 metres. There were no provisions for domestic turbines up until a height of 25 metres. An Environmental Impact Statement (EIS) was necessary for wind turbines higher than 80 metres or groups with more than 3 wind turbines (Sperling et al., 2011). It is important to note that by Danish law, a local plan for renewable energy installations is mandatory if any activity planned such as wind turbines will cause significant change to the existing local environment.

To actualise the Samsø energy plan, Århus County Office for Technology and Environment assisted the island to establish amongst many other items, a zoning plan for wind power. The plan outlined the distribution of wind turbines in six different clusters spread over the southern part of the island, accommodating more than 40 earlier applications for turbine sites on properties around the island. Århus County's responsibility was to appraise proposals by taking environmental considerations into account such as visual and wildlife impacts. As for offshore turbines, the Danish Energy Agency had helped fund preliminary sea floor and other environmental studies. Since support was qualified and minimal landscape impacts were determined, planning permission for the offshore turbines was swiftly attained.

Building regulations on Samsø were largely dictated by Denmark's national building law on energy efficiency of buildings, which had undergone several amendments since 1961. The latest regulations set out a voluntary energy performance framework, which Samsø municipality has since adopted as the nominal compliance framework for special development areas (Denmark Building Regulations, 2010). As a rule, a house in Samsø has to be a minimum 'Low Energy Class 1' standard in order to gain planning permission. This is one of several voluntary energy classes of houses recognised by the Danish building regulations, which also includes 'Low Energy Class 2', 'Passive House', 'Zero Energy Buildings' and 'Plus Energy Buildings'. In Samsø, its spatial planning requirements also dictate that especially dedicated district plans would incorporate district heating networks, while the construction of new buildings in the new districts must connect to the networks according to the subdivisions. However for new buildings that are built as low energy dwellings, mandatory connection to the district heating network is not required. It must be noted that these building and planning rules were not present when Samsø achieved its 100% target, but one could argue that the reaching the goal has prompted these advanced actions.

It took another five years after Samsø reached its 100% target in electricity in 2003 when the national Renewable Energy Act was finally enacted, formally allocating tariffs for all RES. The goal of the new Act was now to encourage local development and growth in the local economy by allowing the general public to reserve future shares in wind turbine sites, by ensuring wind cooperatives' access to a guaranteed fund, by giving municipalities access to green scheme grants to encourage community acceptance of renewable energy, and by certifying access to compensation schemes for RES construction (Denmark Promotion of Renewable Energy Act, 2008). Energinet, the transmission system operator owned by the Danish Ministry of Climate and Energy, was responsible for its administration. Although the Act was enacted after Samsø reached its 100% target, some elements of the law are consistent with the measures undertaken on Samsø in reaching 100%. It is important to note the similarities here.

First, Samsø from the beginning adopted an ownership scheme, giving the island residents the opportunity to invest in several planned windpower projects. In their case, nine of the eleven turbines were to be owned by individual owners apiece, but only with the proviso determined by the municipal government that each owner would also allow space on their land to locate the remaining two turbines, which would then be collectively owned by other island residents through purchased shares. The nine privately owned turbines would also receive support from the municipality in form of bank loan guarantees. In comparison, Denmark's Energy Act also adopts an ownership strategy, which prioritises local residents before commercial interests. The Act stipulate that residents who live within 4.5 kilometres of the planned site for the wind power project must be offered the purchase of shares in the project (at least 20% of the shares), after which the rest of the community could participate. This is applied to ether public or private land. Local cooperatives furthermore had to have at least 10 members living within the 4.5km radius.

Second, like the earlier financing model of guaranteeing bank loans by Samsø's municipal council, the Energy Act also determines that the local windpower cooperative should be supported by a guarantee fund, which is financed by the local windpower operator and the electricity utilities using Public Service Obligations (PSO). Furthermore, these should support the financing of preliminary studies and the payment of the stipulated subsidy during the first peak load hours to the municipalities, which is collected by Energinet.dk through their 'green municipal wind accounts'. Further municipal projects in improving local landscape quality or renewable energy acceptance could be financed through these wind accounts (Sperling et al., 2011).

It should be noted that the Danish Energy Act stipulates that local governments in Denmark should not directly profit from the production of local energy, and that any profits generated must be reinvested into future energy projects.

Although the original Renewable Energy Island brief and subsequent energy plan were designed to anticipate limited national government assistance, politics and election terms were hugely influential. According to the Director of the Samsø Energy Academy Søren Hermansen, the initial national support scheme was very important for the realisation of projects on Samsø because when the incumbent social democratic government was replaced by a liberal-right wing government after the general election in 2002, support for renewable energies dramatically decreased. Since the newly elected government was less supportive of renewable energies, the whole project was placed under huge pressure. According to Hermansen:

> "In the first four, five years, it was a flowing process. But then we had a new government in 2002 and it became more difficult to make projects, because the new government said: 'No, we are not going to support this kind of development, we think that everything should be

> done on market mechanisms in a liberal economy'. As a consequence much more calculations had to be done and also the research area suffered by a lack of financing. Now the government wants to become “green” again, but they missed out on six, seven years. The project almost broke down because of these developments.” (Beermann, 2009, p. 53).

Table 4 gives an overview of the national and regional regulatory frameworks that supported the implementation process in the three municipalities up to the point that they first achieved energy autonomy.

Table 4. Energy-related legislation related existence prior to the municipalities first gaining energy autonomy.

	Wildpoldsried (100% in 2002)	**Güssing (100% in 2001)**	**Samsø (100% in 2003)**
National	Electricity feed-in law, 1991 Federal Building Code (BauGB), 1997 Renewable Energy Law (EEG), 2000 Energy Conservation Act (EnEG), 2001 Energy Saving Ordinance (EnEV), 2002	Austrian Federal Constitutional Law (B-VG), 1930 Environmental Aid Act, 1989	Danish Energy Policy, 1976 Heat Supply Act, 1979, 1990 Energy Plan, 1981 Act for Urban Renewal and the Improvement of Dwellings, 1983 Energy 1990, 2000 Price premium for wind power, 1991 Carbon Tax, 1992 Combined Heat and Power and Utilisation of Biomass Fuels Act, 1992 State-Subsidised Electrical Power Generation Act, 1992 State-Subsidised Completion of District Heating Nets, 1992 Electricity Supply Act, 1996 Energy 21, 1997 Building Regulations, 1998 Energy Supply Act, 1999 Renewable Energy Certificates, 1999
Regional	Bavarian Local Government Law (Articles 89 - 98 GO), 1993 Bavarian Building Code (BayBO), 1997 General Environmental Fund LA21, 1997 Bavarian Agenda, 1997	Burgenland Spatial Planning Law, 1969 Burgenland Building Law, 1997, 2001	National and Regional Planning Act, 1973

4.3.3 Factor 3: Local government discretion

Local government has a higher degree of accountability and responsibility to do better – and certainly no worse – than the private sector. It can use its asset management, capital investment policy and practice to set a powerful example to the community. The facilities owned, operated, managed and controlled by local government are readily available tools – from the urban infrastructure apparatus to the development of municipal buildings, streetlights, car fleets, and undeveloped or underused property. Local government can mandate the highest energy efficiency standards and renewable energy deployment in all municipal buildings. Municipal land can be dedicated for renewable energy installations. They can control the price of renewable heating and electricity through municipal biomass and biogas municipal utilities. Where no public power assets exist, these can be won back, or be newly acquired.

Although setting rules is a traditional role of government, they are not always applied with as purposeful a focus or conviction as might be necessary particularly at the local government level. Some municipalities are more reluctant than others when it comes to attaining greater control and political autonomy when implementing local energy projects, since opposition from the community would be felt much closely than from the national government. However, those that have exhibited some level of political freedom to implement projects have been quite successful even if such 'powers' to act have greatly depended on national level sanction. This situation is demonstrated through the three cases in this section.

Wildpoldsried

In Wildpoldsried, the local village authority did not require special planning powers to implement its energy concept. It relied on existing local planning rules and state regulations. In the Free State of Bavaria, municipalities already enjoy a fairly high degree of political autonomy or right to self-government in managing its own affairs. However, several mandatory tasks are still defined by Federal or State (Regional) laws. Bavarian municipalities for example have to guarantee energy and water supply, wastewater services and waste removal, and municipality territory planning by specifying residential, commercial and other areas. This has to be regulated through a land use plan and building plan, a building approval procedure, and a local authority land policy, which includes a land order, dispossession procedures and public investment requirements. The manner in which the municipality fulfils this task is its own affair.

In relation to energy supply, the municipality can operate its own energy utility, but it can also obtain its energy from other independent providers. According to the provisions of the Bavarian Local Government Law (Articles 89 - 98 GO): "the municipality can only set up, take over or expand an economic enterprise if the public wellbeing requires this company, if the size and type of the company is in relation to the capacity of the municipality and its probable need and if the purpose cannot be fulfilled just as well and economically by another party" (Translated by Born, 1997). This provision set the basis of Wildpoldsried's village development company (Dorfentwicklungs-GmbH), which was established in 2005 to implement the village district heating. As for the planning and consent for the remaining renewable energy installations in the village: 11 wind turbines, 5 biogas plants, 4 biomass-pellet systems, 3 hydro electric plants, 5 shallow geothermal installations, 2100 m² solar thermal and around 4690 kWp of photovoltaic panels (http://www.wildpoldsried.de), these were wholly approved by the village council in a timely manner. Since installations were owned and operated by the villagers themselves, some who were also members of the village council, the individual projects were swiftly granted. The only delay concerned the village's ecological water management system, which required health and safety input from the regional water authority.

Güssing

In Güssing, the local authority also did not require any extra jurisdictional capacity to carry out its projects. They were able to engage the rest of the council, the regional utility, and research institutions from around the region to help them implement the necessary renewable energy installations. By creating the EEE as the body responsible for coordination and operations, with private industry as the operational members, the local authority was able to manage the entire network of renewable energy systems with ease. Because most of the installations were largely owned and operated by private limited companies (with the municipality as 51% stakeholder), significant risk was borne by the companies themselves. This type of ownership setup, like in Wildpoldsried, made the need for extended local authority planning controls unnecessary. By relying on the integration of a wide range of private stakeholders for the development, construction and operation of the facilities, the local authority could solely focus on streamlining permitting processes and mobilising funds.

The municipality was able to carry out energy projects since it was endowed by regional provisions to manage energy distribution. The provisions also relate to law and order, health, sport and leisure, the environment and transport. Its local spatial planning laws are similarly prescribed by the region in the form of the Planning Act of Burgenland (Bürgenländisches Raumplanungsgesetz), which stipulates the discretion of the municipal council to carry out local planning. In general, municipalities in Austria are permitted to act as sovereign planners and economic bodies, and are given a wide range of opportunities for self-government and regional development. Furthermore the Austrian constitution law stipulates that local authorities should play an exemplary role in reducing the greenhouse gas emissions in the building sector through the efficient energy management and the use of renewable energy sources in all buildings (Article 15a B-VG Agreement). Although national policies can override local planning, for example in the management of the national high voltage power grid network, these instances have not occurred in Güssing.

Indeed, national law generally dictates that actions by municipalities must be consistent with policies and regulations by the province and national governments, in particular with regards to the tools to govern building and spatial planning. Municipalities for instance must prepare a development plan that defines the long-term development of the municipality in terms of its functions, organization and goals in building, land and infrastructure as well as the development of the population and economy. They must prepare a zoning plan that allocates different land-use categories, mainly to building land, transport areas and green zones. The zoning plan indicates the allowable land uses, but with no stipulated obligation to implement the uses (e.g. housing) (Tosics et al., 2010). They must also have in place a building regulation plan for selected areas of building land that is subsidiary to the zoning plan. Public participation and cooperation in planning processes is also a requirement, which is to be managed by the local authority. Despite the stipulated municipal discretion, 'local' tasks remain subject to national intervention.

Samsø

In Samsø, a community cooperative model negated the need for the municipality to seek further powers to implement its energy plan. There, the process was swiftly administered by the municipality by first establishing community working groups, which helped inform residents about the projects, second deciding collectively on the appropriate sites and technologies, and lastly, determining the ownership structure for the different installations. Such agreements made the projects accessible and relevant to the island's community, which meant that the responsibility for their implementation rested in the hands of the community stakeholders and not entirely on the local authority.

As the engagement process took place, the municipality undertook the usual practice of managing the permitting and subsidy processes. It guaranteed mortgage loans that financed the district heating stations, whose fuel straw and wood chips were produced by local farmers. It organised information evenings and seminars to ensure increase participation by the local residents. It ensured that project proposals for RES installations also complied with existing national building and energy standards, even though at the time, standards for the construction of energy plants or small-scale decentralised plants was yet formalised. By the time Samsø reached the target of 100% self-sufficiency in electricity in 2003, *extraordinar*y powers was still not necessary.

Samsø, as with all Danish municipalities, already enjoyed a reasonable degree of freedom in carrying out its functions and powers, a political autonomy that was underscored by the Danish constitution. Like in Wildpoldsried and Güssing, the local government was guided by the national government in the tasks that it was mandated to execute, but how this was to be developed and managed was left to its own discretion. Local problems meanwhile were to be addressed and resolved through frequent communication with the local population.

As dictated by national law, Danish municipalities must undertake necessary planning which includes establishing municipal plans (Kommuneplan), which are binding, and includes frameworks for local planning (policies, maps and land use regulation for the total municipal area). The municipalities also have the capacity and obligation to prepare and implement local plans (Lokalplan), which include maps and land-use regulations for specific neighbourhood areas. Like in Wildpoldsried and Güssing, municipal plans must be consistent with regional and national policies. Although the municipal plan was declared as the most important plan in Denmark when local governments were restructured in 2007, neighbouring municipalities can still object to a plan, and the national government can still veto a plan if it contradicts with regional or national interests. Like the Bavarian law, Danish law also stipulates that municipalities are entitled to carry out their own projects. They may for example run and develop a particular kind of business, or purchase land to endorse a preferred urban development model. However profits earned from the municipal projects must be reinvested in future projects as Danish law does not allow local authorities to profiteer from community projects. This is pertinent for municipal energy projects that involve local energy production. Since municipalities in Denmark are often major landowners, it is unsurprising that Samsø pursued the establishment of the Samsø Energy Company, and later the Samsø Renewable Energy Company Ltd, to implement windpower and district heating networks, for the benefit of the entire island community.

One could argue that the ease at which the municipality operationalised its energy plan was the result of national government intervention several years prior to it attaining energy autonomy. For instance, the local government reform of 1999 for wind power, gave Danish municipalities the possibility to point out future locations for wind turbines in their new municipal plans. Wind turbines could be built only after the municipal council had prepared municipal plan guidelines that describe the turbines' location and design. They were also allowed to establish a utility company, which could then receive a loan from the municipalities' own financing company (KommuneKredit) to finance the project. By 2009, extra powers were conferred to the Danish local authorities when the formal responsibility for reserving wind turbine sites was transferred from the former Counties to the municipalities. Accompanying this change were also new codes that extended the height limit of wind turbines to 150 metres, and increasing the minimum distance to neighbouring wind turbines from 2.5 to 4.5 kilometres. Even though this conferring of power from the County to the island did not have any impact in Samsø first achieving its 100% target in 2003, it did show the heightened level of trust placed in the municipalities by the national government by that time. Like Wildpoldsried and Güssing, Samsø succeeded on the basis of self-governance, thereby enabling them to control their own sequence of development.

4.3.4 Factor 4: Local government organisational change and augmentation

The Delphi expert survey revealed that local government should rethink the manner in which they administer energy planning and urban development if they wish to pursue energy autonomy. Can the existing setup manage the range of actions required to achieve 100% renewable energy autonomy, or is an external body that is connected to the local authority essential to pursue the goal? In this section, I show that the three municipalities did not require any radical changes in its administration, but augmentation was necessary.

Organisational change

Wildpoldsried

In Wildpoldsried, the genesis of their 1999 energy plan was based on earlier conversations and discussions within the village council to determine the priorities for local government. The main questions were how "they could better involve local citizens and how Wildpoldsried might look like in 2020" (Pahl, 2012, p. 211). In 1998, the village council carried out a citizens' survey to develop the village's ecological profile, establishing the basis for a local citizen participation process. It showed that citizen approval for an energy concept was high, with 90 percent of the community fully supporting the construction of local wind turbines. In the following year, the village council conducted its first evaluation for a district heating system in Wildpoldsried. For many years, the municipality's goal was to replace all old oil heaters in the buildings with biomass heating systems. The assessment finally found that the system was not viable because it was necessary to first lay a pipe network and ensure that the heating plant was centrally located. Indeed it took another four years of intensive planning before a wood pellet heating system was finally installed and the heating network constructed under the street, supplying heating to all public and some private buildings by the end of 2005. The construction of a new community hall in the central village square had by then provided the necessary space for the heating plant. The development of the plant and network, and subsequent expansions benefited from regional development grants for RES and co-financing by the EU in later years (2007, 2009 and 2010). Similarly, the development of local windpower and particularly the windfarm proceeded largely due to the mobilisation of interested local farmers and residents to form a community windpower cooperative. Regional and EU investment were once again critical in these instances.

Although the above actions did not entail formal changes to existing planning practice and organisational setup, it did result in the creation of the Village Development Company (Dorftentwicklungs GmbH), a subsidiary company owned by the village municipality to operate the district heating plant and network. The company resided separately to the local government structure but accountable to municipal rule. Within the administration, the municipality rested on the actions of an energy commission composed of government councillors and prominent members of the community, to decide on energy policy, implementation of the municipal energy plan, and reporting to the European Energy Award® and the wider community. Although placed separately from other municipal departments, the commission's members worked to raise awareness of the locality's energy concept throughout the entire administration. The commission's significance was heightened by being led and driven by the mayor himself. The engagement of the Allgäu Energy and Environment Center (Energie- und Umweltzentrum Allgäu - EZA), a regional energy consultancy company, meanwhile ensured access to continual technical and logistical energy advice, which was further augmented by incorporating an EZA energy consultant as part of the municipal energy commission.

By keeping existing building and permitting processes to manage the different renewable energy installations, each energy project in Wildpoldsried was treated as any local development scheme. By weaving small measures in a consistent and fairly low-key fashion, projects were expanded, built upon, diversified as a matter-of-course, and therefore *normalised*. They became part of the daily operations and responsibilities of the municipality. Actions related to energy became just as standard as providing local services in waste and water. According to its mayor, “begin with small measures and take them successfully to an end. Then act as a model with your own buildings, with respect to energy efficiency and production of renewable energy. Set up an energy team and as time goes by it will be taken for granted” (CIPRA, 2010b). For the mayor, implementation for energy autonomy must become a matter-of-habit. "Our children don't know anything else,' he says. For them, the wind turbines belong on the mountain and the photovoltaic panels on the roofs of the village are just part of the picture” (Pahl, 2012, p. 216).

Güssing

In Güssing, local authority evaluations did not so much concern building and planning frameworks as ascertaining ways to optimise the use of local renewable energy resource potentials in order to fully displace local fossil fuel consumption. The issue was first tackled by using existing expertise to conduct a Strength, Weaknesses, Opportunities and Threats (SWOT) analysis for living and working. The analysis revealed that locals were paying over €6 million for heating, largely due to household oil-fired systems; and with the help of the regional forestry association, it was also revealed that there was a huge availability of regional biomass, an ideal resource for district heating. As a result of the analysis, three major resolutions were passed by the municipality and its mayor: first, to create an energy study on the future energy supply (Decision 13.07.1993); second, to encourage the participation of the municipality in the Güssing District Heating Ltd (Güssinger Fernwärme GmbH) (Decision 24.11.1994); and third, to provide a special plot of land for the construction of the district heating (Decision 19.03.1996) (EEE, 2012).

Momentum was established by initiating new projects every 2 or 3 years, with projects built upon the success of earlier ones. Basic energy saving measures in the town (thermal building renovations of public buildings, street lighting improvements) began in 1990, which were then followed by the construction of small district heating plants in villages around Güssing in 1992. The building of the district heating plant in 1996 was followed by the foundation of the European Centre for Renewable Energies (EEE) that same year. When the Güssing demonstration biomass power plant was built in 2001, the town had reached 100% energy self-sufficiency in electricity. A string of facilities was built in subsequent years, notably the Strem Biogas demonstration plant (7 km from Güssing) in 2004, and the Bio−SNG demonstration plant and Institute of Technology four years later.

The municipality did not concentrate so much on planning processes as finding ways to facilitate and accommodate the renewable energy technology needed to be developed and be integrated into the municipality. Since local government support was present from the outset – since they were also the main initiators - planning approvals were academic (although projects were still subject to environmental impact assessments). All in all, most projects were carried out with ease through existing administrative arrangements. There was no need to reorganize the existing local government departments. The only change related to the establishment of additional entity to handle coordination. It became necessary to establish the EEE as a separate association to manage the growing number of energy plants and networks as well as oversee the development of the larger, key demonstration projects such as the seminal biomass gasification plant. Although not part of the local government, the Association was able to maintain close cooperation with them, especially since the organization was presided by the mayor. To disseminate the Güssing energy concept as a business model, the private limited company (EEE GmbH) with the same name as a 100% subsidiary of the Association was also established. To implement other district heating or biomass power plants, separate private limited companies were founded. In the district heating company for example the municipality as a stakeholder maintained a 51% share. Overall, the Güssing model has demonstrated that the high level of expertise required to construct and operate such sophisticated facilities warranted a degree of separation.

Samsø

In Samsø, the formulation of the 1997 Renewable Energy Island plan required careful consideration of the energy resources available and the stakeholders participating. The plan itself was formulated, not by the local authority, but by PlanEnergi, a Danish independent consultancy firm specialising in renewable energy, environment, sustainable systems, energy planning and technology transfer (http://www.planenergi.dk). They investigated the available resources and made a timetable for the project. The initiators of the project, the mayor and local engineer, recognised earlier on that the plan depended highly on local ownership, and therefore the local administration had to consider ways to facilitate this engagement. The public participation process thus became the most critical component, more so than in Wildpoldsried whose community were already long-standing supporters (and implementers), or even Güssing, where community ownership was not vital since private companies could be relied upon to carry out the necessary work.

In order to operationalise the Renewable Energy Island plan, the planning process in Samsø had to accommodate advance measures in public engagement and participation. The developers of the concept knew that a top-down planning approach would not be the right approach because this may cause disputes amongst land-owners and consumers, for example when locating wind turbines or convincing households to switch from oil based units to a district heating system based on renewable sources. But in engaging local teacher Søren Hermansen to head the energy committee, the implementation process was seen to be clearly led and driven with the community's interests in mind. Beginning with invitations to the community to participate in workgroups for the planning and development of the local renewable energy projects, the meetings provided the opportunity to inform the local residents about the costs, payback time, and possible technological solutions. But most importantly, following this stage, they were left to determine their own ownership and management agreement. The continual feedback process enabled ideas and methods to naturally evolve and to allow strategies to change along the way. More residents would join the groups as the message is disseminated.

Like in Wildpoldsried, the Samsø energy committee was embedded within the local government department structure and incorporated the original initiators of its energy plan, as well as local and external experts. Like Güssing, it also created separate entities outside of the administration – in this case two local agencies: the Samsø Energy and Environmental Office (SEEO) to promote renewable energy and its installation by local citizens, and Samsø Energy Company (SEC) to begin construction of the wind turbine and district heating projects. With their own resources, the municipality began implementing its plan with the support from the Samsø Business Forum, Samsø Farmers Association and Århus County Office. From the very start, the SEEO and SEC worked either together or individually to organise campaigns and meetings. Joint meetings allowed holistic discussions on technical, conceptual or social aspects of the projects. When SEC was shut down by 2005 and replaced by Samsø Renewable Energy Ltd, it enabled the municipality to establish its own offshore wind turbines. By 2007, the Samsø Energy Academy (SEA) was created as a central meeting place and laboratory for the local government, energy experts and the community to collectively discuss issues concerning energy and local development. Like the EEE in Güssing, the SEA also conducts research, organises workshops, conferences and exhibitions, and runs training programs in energy.

By creating several locally based organizations, either municipal or cooperatively owned, to manage the construction of energy projects in Samsø, changes to the existing administrative and planning frameworks had not been necessary. In fact, it eased development because funds were better specifically directed and people purposefully engaged. Existing as 'satellite entities', such organisations revolved around the existing local government structure rendering individual renewable energy projects not only special but given an elevated status above daily municipal actions.

Augmentation via public-private partnerships

In all three municipalities, public-private partnerships (PPP) were critical to the implementation of the energy plans. The PPPs for energy autonomy generally consisted of four active networks: the political network (local, regional and national government engagement), the research network (regional and international institutions responsible for research and development (R&D), the industry network (private entities for construction and operations in energy generation and supply), and the community network (efforts of the population). Although direct community participation was not always found to be absolutely necessary to achieve the 100% target, as was the case of Güssing in Austria, this instance was only possible because activities in local energy was already well accepted amongst residents. Acceptance is therefore an assumed and necessary prerequisite for other networks to function. Through the PPPs, financial resources were raised collectively, risks shared, trust and accountability fostered, on-going feedback ensured, program longevity maintained, and innovation nurtured.

Table 5. Key partners of the municipalities.

	Wildpoldsried, Germany	**Güssing, Austria**	**Samsø, Denmark**
Political network partners	Municipality of Wildpoldsried Free State of Bavaria Federal Environment Ministry European Union	Municipality of Güssing Province of Burgenland Ministry of Economics and Labour European Union	Municipality of Samsø Århus County Danish Energy Agency European Union
Research network partners	Allgäu Energy and Environmental Centre (EZA)	Technical University of Vienna Technical University of Graz RENET Austria Institute of Sustainable Technology (AEE)	Kremmer Jensen ApS PlanEnergi
Industry network partners	Village Development Company European Energy Award® Allgäu Überlandwerk (AÜW)	European Centre for Renewable Energy (EEE) Burgenland Forest Association Energie Versorgung Niederösterreich (EVN) Repotec	Samsø Business Council Samsø Farmers Association Samsø Energy and Environment Office Samsø Energy Company Samsø Offshore Wind Co Samsø Energy Academy Samsø Energy Agency NRGi (formerly known as ARKE)
Community network	Local farmers Some residents	Local farmers Few residents	Local farmers Most residents

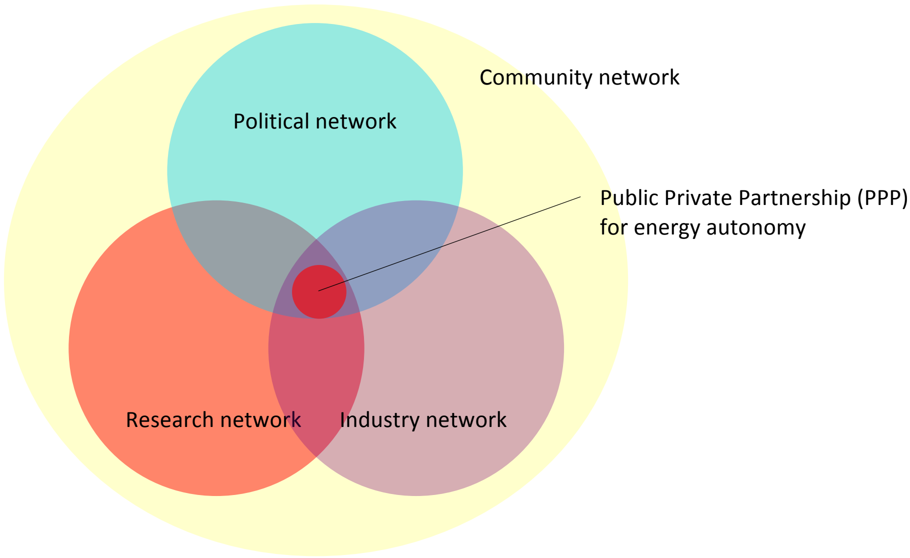


Fig. 86. Key working networks, with community acceptance as a prerequisite.

Wildpoldsried

In Wildpoldsried, the contractual relationship between EZA, the regional energy consulting company, and the local government enabled the village council to promote renewable energy, provide advice on energy conservation, develop the municipal energy management plan and support municipal reporting to the European Energy Award®. It also helped create an energy inventory, manage and control the energy supplies on a monthly basis, regulate energy use through monitoring systems that could immediately notify users of spiking energy consumption, deploy a municipal energy management system based on the ISO 14000 Environmental Management Standard, and advise on the issue of energy certificates. With the help of EZA, municipal building managers were also supported and trained in local energy management.

There were also agreements with the regional energy provider, the Allgäu Überlandwerk (AÜW), to provide green power certification, energy consulting for households and businesses, and power meters for hire. The utility's commitment to renewable energy and its transforming association with local consumers, was expressed in the words of its CEO Michael Lucke: "the utility aims to generate by 2022 about 70 percent of the electricity used in the Upper Allgäu from renewable sources. Here, the relationship between producers and consumers will change dramatically. The consumer is becoming a partner that also produces its own energy [as] 'prosumers'" (Lucke, 2012).

Wildpoldsried's participation in the European Energy Award® Scheme has motivated action on municipal energy policies, and adherence to rules on monitoring, auditing, reporting and certification of energy projects. This relationship with the award scheme has also maintained interest; and engendered pride and a willingness to do even better, especially since participating communities were regularly compared to one another. Meanwhile, the municipal development company (Dorfentwicklungs GmbH) has worked to generate profits generated from the local district heating systems for the benefit of the entire community, as monies earned are re-invested in other village projects. A community energy cooperative has also been instrumental in the development of the local windpower farm, led by the village's farmers, and contributing to significant supplies of windpower and thereby income.

Güssing

In Güssing, the partnerships established between the local authority, research institutions and private companies were key to its success. The EEE was the primary coordination centre, which managed the partnerships for the construction and operation of the renewable energy plants, oversaw the framework for research and development in renewable energy, and protected the interests of associated industries and chain of suppliers. Through the EEE and by establishing the regional competence network, RENET, responsible for the 'Competence Network for Energy and Biomass', the local government was able to link themselves with research institutions, local companies, and industry. For example, the engagement of the University of Vienna and the Technical University of Graz resulted in the development of the world's first demonstration CHP plant in Güssing, based on the Fischer-Tropsch process, a system, which gasifies biomass for the production of heating and electricity. With the EEE attracting many solar energy companies interested in powering their manufacturing facilities with renewable energy to the district, this also contributed to the growing reputation of the municipality as the leading centre for renewable energy research. With the support of the local authority, the EEE was able to persuade global solar cell manufacturer Blue Chip Energy to set up business in the municipality. As of 2013, the EEE consisted of 60 members, which include the AEE Institute of Sustainable Technology, the local electrical utility, Energie Versorgung Niederösterreich (EVN), and other local firms and private persons.

It is important to note that despite the 51% stake in the EEE and the mayor of Güssing presiding over the Association, the municipality does not have control over the running of the Association.

The organisational framework in Güssing was essentially based on the cooperation of three main parties: the scientific team, the industrial associate, and the local government. This permitted the collaborators to try out ideas and learn from each other, thereby accelerating the development of work in Güssing (Hofbauer, 2007). By continually assessing the markets, available energy sources, and optimised mix of technologies, the scientific team was able to maintain credibility in the energy plan, and security in the engagement of long-term partners. By establishing a contractual framework with local energy installers for small-scale renewable energy systems and local farmers for the sourcing of locally produced biomass, the industrial associate was able to guarantee stable energy prices for local farmers as bioenergy croppers, enabling them to generate income, both in the raw material supply to the plants and in the energy delivered from them. By charging fees to buildings connected to the district heating network, the local government was able to secure on-going finance for future projects from the returned profits.

It has been argued that the inherently top-down model was "elitist" and did not sufficiently encourage the participation of the local community in Güssing, while the various demonstration projects have added to the technocentric elitism of the Güssing concept (Sieberth, 2012). Despite this there has been no indication of unhappiness amongst the population, in fact, most have been able to benefit from the new local supplies with very little personal effort, enjoying the rise in employment opportunities and improved public infrastructures.

Samsø

Compared to Güssing, the wider range of partnerships in Samsø evolved as a consequence of the imperative need for local community engagement to drive the planning and development process. In Samsø, the policy was for citizen groups to formulate their own ownership arrangements for the construction and operation of the individual renewable energy installations. The complexity entailed in the distributed installations similarly required a distributed form of local ownership and stakeholder types, depending on the location. Purely private, purely public (e.g. cooperatives) and combination entities have thrived on the island.

At first, the original energy plan required the input of the municipality, the energy planning company PlanEnergi, the Samsø Commercial Council, the Samsø Farmers Association, and the local utility ARKE. This group of island-based organizations then had to work together with community leaders and their groups, which by then were selected by the Samsø Energy and Environment Office (SEEO), to implement the plan. In the first years, the technical and financial framework defined by Samsø Energy Company (1998-2005), helped coordinate the construction of several wind power and district heating projects. This was followed by the establishment of Samsø Offshore Wind Co, which realised the construction of several offshore wind farms. This company also involved the commercial council, farmers association, municipality and the SEEO, all as co-owners. These partners became the main driving force in the operationalisation of Samsø's energy plan. Samsø Business Council connected local entrepreneurs on the island, and stimulated exchange of knowledge of the economic benefits of the energy strategy. Samsø Farmers Association connected and informed its agricultural farmers of the savings in fuels and income from the construction of wind turbines on farms. The municipality provided the regulatory and policy framework to manage the permitting processes, while the SEEO continued awareness raising of energy efficiency and renewable energy to the wider community.

In Samsø, several early offshore wind turbines were owned either exclusively by private commercial interests, or by small (1500) shareholders through established companies (n=3, 2 respectively). By 2010, there were 9 privately owned onshore wind turbines owned by local farmers, one straw district heating system owned by a local commercial operator Kremmer Jensen ApS, as well as many private household installations - 860 solar thermal systems, 35 heat pumps and 120 biomass-based units (Rosa & Svendsen, 2011). Despite the growing private ownership of systems, Samsø's community energy cooperatives also flourished. By 2010, there were two community wind turbine cooperatives, and three district heating cooperatives in operation. Two of the district heating systems were managed by the regional utility, NRGi, as owner-operator, while the other was owned and financed by the consumers themselves. (Incidentally, NRGi is cooperatively owned). Indeed the cooperatives have acted not just to provide an alternative strategy to centralised organisation, but to also dampen any setbacks associated with disagreements between (former) parties. In the case of the consumer-owned Ballen-Brundby district heating system, its genesis was the result of the municipality and local citizens engaging small, local energy company Kremmer Jensen ApS after the regional energy provider ARKE (later NRGi) had decided to exit from the implementation process. (PlanEnergi & Samsø Energy Academy, 2007).

Another important partnership for the municipality was with Århus County government, which enabled the municipality to improve connections with other research centres and renewable energy organizations in the County, and to undertake fundraising activities, such as applying for EU grants. It was also instrumental in assisting the municipality with the development of the district zoning plan for wind power and the appraisal of local wind power construction.

Positioning of stakeholders according to their power-interest in local energy development

The following graphs (Fig. 87-89) outline the relative importance of the main partners in the operationalisation of the energy concepts by the three municipalities. The graphs indicate that local government entities tended to have the greatest degree of empowerment and interest. National and regional government entities displayed moderate interest: functioning as an umbrella entity that overlooked local management, information, monitoring and general compliance. Development-cooperative entities played a pivotal role in maintaining and continuing operations.

The power-interest matrix is a simple tool to categorise actors in a project and to determine their influence over a project. It presents a model that represents the dynamism between actors and their individual power relative to the project (Johnson & Scholes, 1999).

Legend

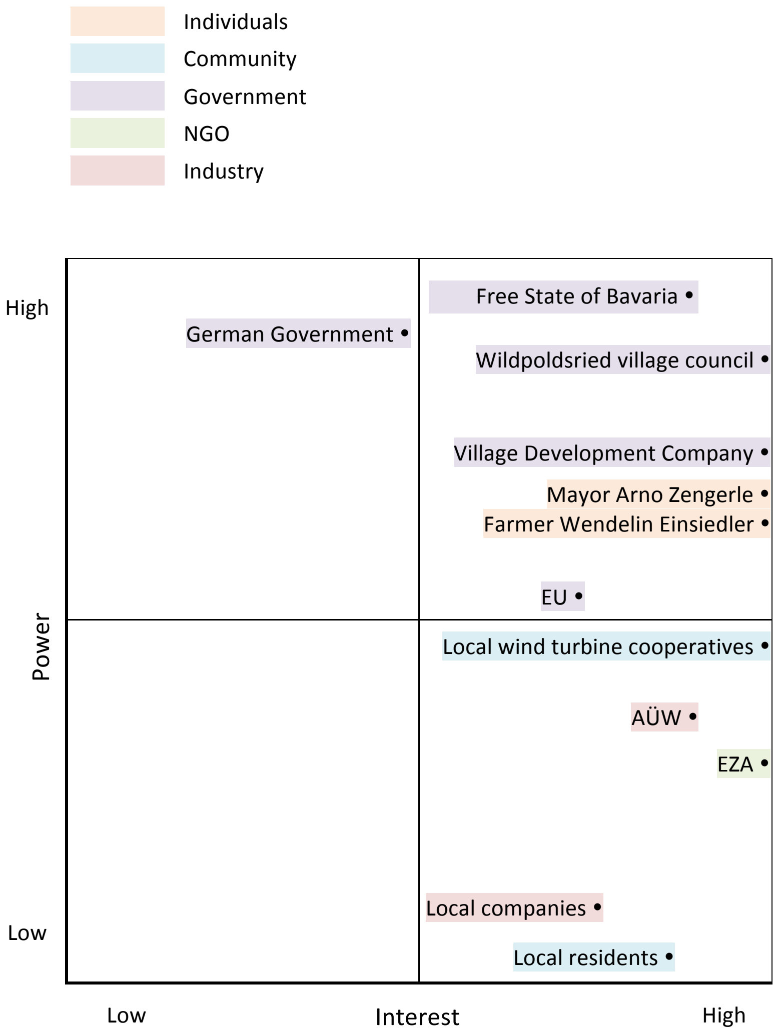


Fig. 87. Power-Interest diagram for the municipality of Wildpoldsried.

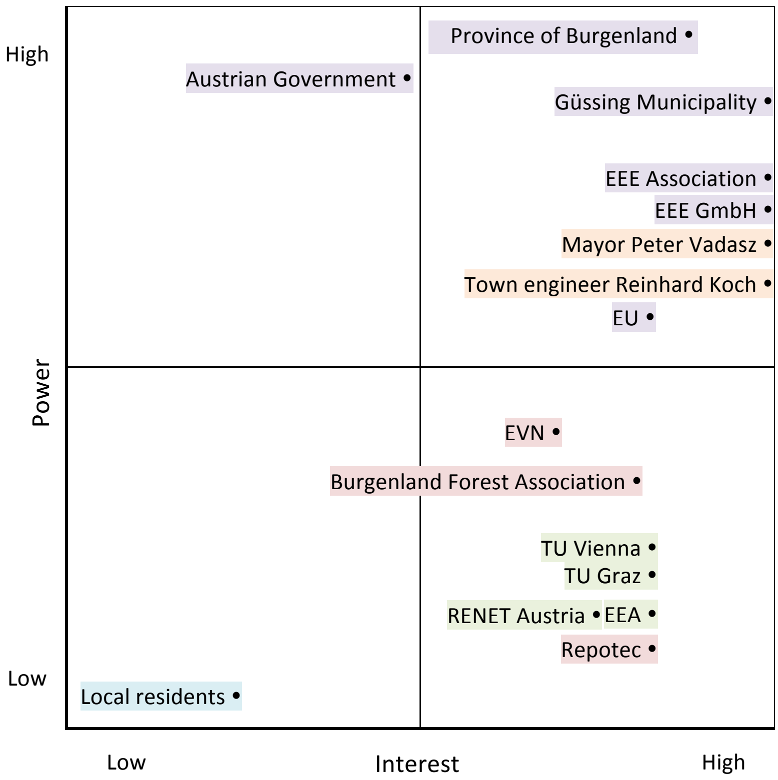


Fig. 88. Power-Interest diagram for the municipality of Güssing.

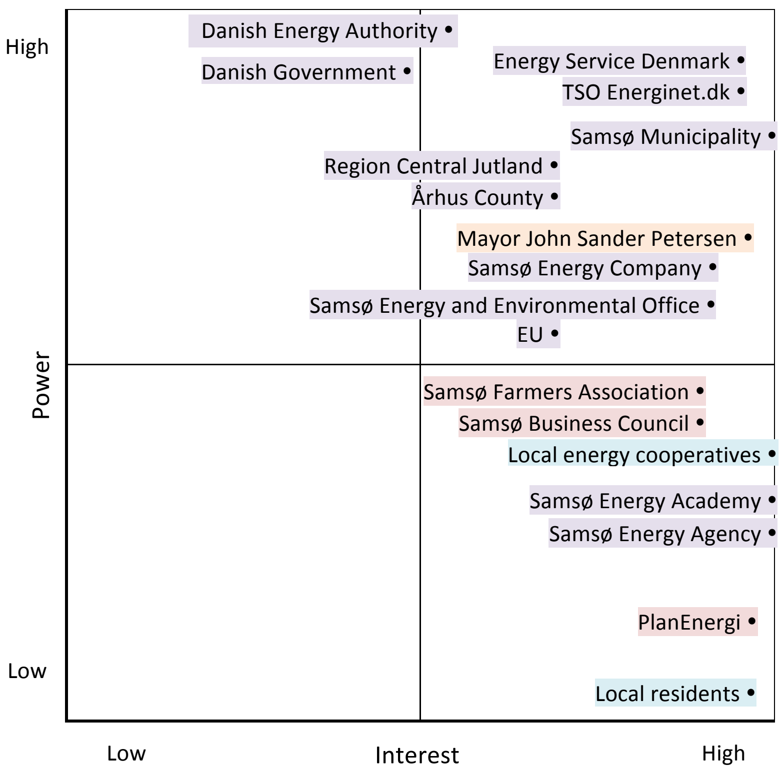


Fig. 89. Power-Interest diagram for the municipality of Samsø.

4.3.5 Factor 5: Local leadership for energy autonomy

In all three municipalities, local champions led the initiation of energy plans and guided the establishment of public-private partnerships to operationalise the plans. In this section, I explore the degree of influence of certain individual or individuals in the conception and implementation of the community's energy vision.

4.3.5.1 Local champions

Wildpoldsried

In Wildpoldsried, mayor Arno Zengerle, and local farmers Wendelin Einsiedler and Ignaz Einsiedler were the early pioneers of the village's energy vision. As highly respected locals in the community, they were in tune with the community's immediate problems and needs and were not reticent to proffer their vision to the community. Wendelin Einsiedler in particular was instrumental in forming the first local energy action group in 1999, which involved thirty of his neighbours to move forward with the renewable energy portion of Wildpoldsried's 3-part ecological plan. By 2000, the group had organised a company that erected two Enercon E-58 wind turbines with a combined output of 3.5 MW. This was followed by the creation of a second company for 2 more turbines totalling 4.5 MW in 2001, and a third turbine in 2008. By 2002, the turbines enabled Wildpoldsried to achieve 100% self-sufficiency in electricity.

Mayor Arno Zengerle was above all responsible for the formulation of policies and the application of Bavarian State funding, while the farmers were responsible for the technical aspects of implementation. General energy advice, a service provided by the village council, was the responsibility of the external energy consultant from EZA. The mayor also oversaw the development of the municipal development company (Dorfentwicklungs GmbH) and was active in regular council and public meetings, providing constant community briefings on the village's achievements. He also led the Wildpoldsried energy team, which was established to ensure accurate reporting to the European Energy Award®.

As a visible figurehead, the mayor provided a 'face' to the energy vision. As members of both the council and energy team, the farmers highlighted the energy plan as a contextually-bound grounded strategy, impacted by natural, cultural and economic dimensions of their locality.

Fig. 90. Local farmer Wendelin Einsiedler, known locally as the 'wind pope' (http://www.wildpoldsried.de).

Güssing

The operationalisation of the Güssing energy plan was driven by three major actors: the mayor Peter Vadasz, local engineer Reinhard Koch, and scientific director Prof Herman Hofbauer from the Technical University of Vienna.

As 'policy builder', mayor Peter Vadasz utilised his skills to overcome political resistance and to manage the legal ramifications of implementing the required projects. He mobilised resources and brought together interested local parties. He led the way throughout the entire implementation process and was key to initiating the construction of the biomass gasification plant, the facility, which enabled Güssing to reach the 100% target in renewable electricity. As 'technical builder', local engineer Koch weighed the availability of the natural resources against the technologies required to source them. He coordinated the individual projects and maintained an overview of operations so they were consistent with the original aims of the municipality's energy concept. As a 'system builder', Hofbauer was not just responsible for the development and construction of the biomass plant in 2001 and subsequent demonstration plants, but he also mobilised funds, employed research staff, engaged industry partners, and attracted a string of European research programs. Experimentation was encouraged and knowledge was diffused. He established modes of cooperation with the competence network RENET, in collaboration with the municipality of Güssing, the AEE – Institute of Sustainable Technology, Technical University Vienna, REPOTEC, and the local electrical utility, Energie Versorgung Niederösterreich (EVN). The network received funding for seven years from the Austrian Ministry of Economics and Labour.

Fig. 91. Prof Herman Hofbauer, Technical University of Vienna (http://www.tuwien.ac.at).

Samsø

Although local mayor John Sander Petersen and local engineer Bent Schaloffsky were originally instrumental in entering Samsø into the Renewable Energy Island competition, actual implementation was largely driven by local environmental teacher and energy advisor Søren Hermansen. With local participation being core to the energy plan, citizen mobilisation was critical to minimise resistance, ascertain the availability of land, and secure funds. The task for Hermansen was to therefore sensitize the local community of their own capacity to develop an energy project. Instead of a top-down procedure devised by politicians and specialists, was a bottom-up process, which was managed by the people themselves, and motivated through social pressure. Through several rounds of information evenings, the first residents who would join and become active would prompt other residents to follow, thereby normalising participation, and even engendering competition throughout the community.

The role of Søren Hermansen should not be underestimated. As a longtime resident, he was able to quickly convince and gain the trust of island residents. Local farmer Mogens Mahler remarked: "He is born and has lived on the island for many years. So everybody knows him, and everybody knows that he is not doing it for his private [sake], but he is doing it for the island" (Beermann, 2009, p. 42). As a local, he was able to establish *short lines of communication* between those in charge of policy (councillors) and those in charge of implementation (the residents). Another local took note of his ability to empathise quickly with the locals: "We had citizens' meetings in all the villages around and most of them were farmers. And when they got a little stubborn, Søren could switch into the local dialect and he just had them" (Beermann, 2009, p. 42). Today, Hermansen is the director of the Samsø Energy Academy, where he promotes Samsø's achievements to politicians, journalists and visitors from around Denmark and abroad.

As for mayor Petersen, very little has been reported on his role in the island's energy transition besides his recognition of the business opportunities entailed from entering the Renewable Island competition. Samsø's latest mayor Marcel Meijer (as of 2013) in comparison is actively involved and has a seat on the management board on the Samsø Energy Academy, responsible for monitoring projects and advising on local policy. Similarly, engineers Bent Schaloffsky and Aage Johnsen Nielsen, who were originally involved in the technical side of implementation, and Birgit Bjornvig, a local politician and former member of the European Parliament, who was involved in the initial lobbying of the energy concept, have also not received as much attention even though they have been indispensable in the process. Unlike mayor Zengerle in Wildpoldsried, and mayor Vadasz in Güssing, Hermansen was the only non-mayor to be the 'face' of the municipal energy plan.

Fig. 92. Director of Samsø Energy Academy, Søren Hermansen, former local teacher and farmer (http://www.newsworthy.coa.edu).

It is worthwhile noting that each municipality required a set of two key individuals from the outset to initiate and implement the energy plan. One, usually the mayor, to handle the legal ramifications and another, usually a local champion, to oversee the practicalities of implementation, often in terms of the technology required. In the case of Samsø, delegating the responsibility of construction and management to residents as cooperative entities also became a practical and social priority. And once an energy plan was established and normalised, the presence of a *third* key individual was necessary to maintain long-term motivation and consistency in terms practice and knowledge development, as was the case of Prof Hofbauer in Güssing and Søren Hermansen in Samsø.

4.3.6 Factor 6: Local energy potentials models

There were no energy potentials models such as STEM employed by the three local authorities but some form of local energy planning was carried out. For each case, it was essential to first take stock of the available local resources at hand in order to develop an inventory of the natural, infrastructural, social and economic resources. This meant undertaking some analysis - information which then informed the development of municipal energy plans. With further monitoring and feedback, the effects of early measures could then be assessed and future actions planned.

Wildpoldsried

In Wildpoldsried, the development of alternative funding models and the implementation of future plans and projects relied heavily on statistical evaluations of energy activities, such as the yields of photovoltaic systems and heat consumption values. Energy advisory company EZA largely undertook these analyses as well as thermographic modelling of local roofs in the village. This activity for example, enabled the local government to show local residents how much heat – therefore energy – was lost, compelling the locals to install or improve the insulation of their homes. As for analysis carried out by the village council, a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for living and working in the district had found that locals were collectively spending millions of euros in oil-fired heating. This was in the face of the large availability of biomass resources in the area, which was finally found to be sufficient to power an entire village-wide district heating system. In recent years, regional online energy potentials maps enabled the municipality to devise their own planning maps denoting areas of existing and future wind turbines.

Fig. 93. Thermographic imaging for local residents (http://www.wildpoldsried.de).

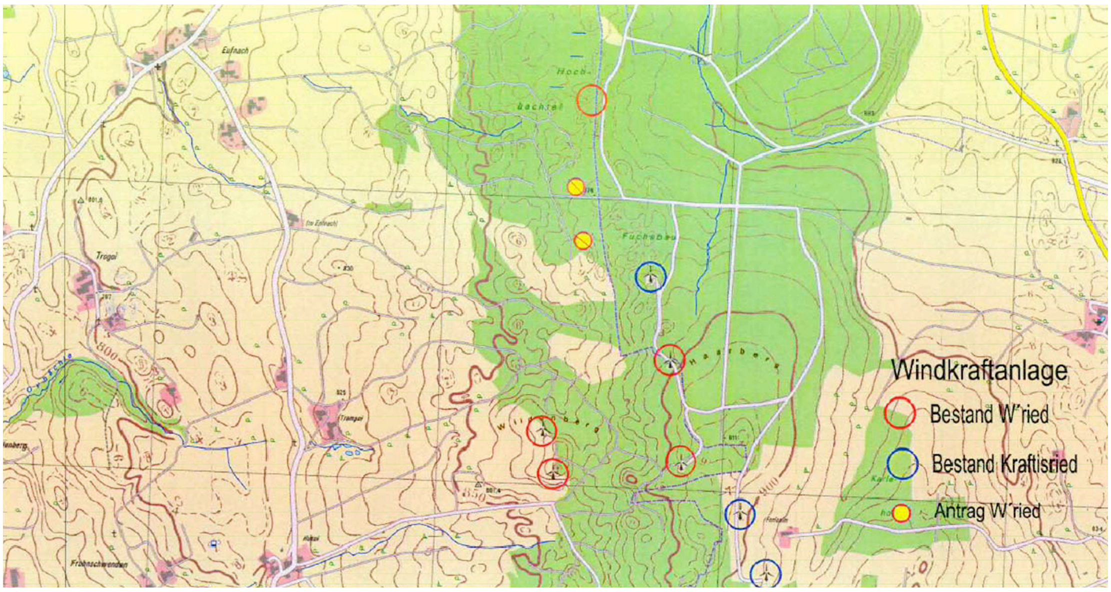


Fig. 94. Plan for local windpower turbine installations (http://www.wildpoldsried.de).

Güssing

In Güssing, the 1991 energy concept similarly involved the determination of energy demand, energy savings potential, CO_2 emissions, resource potential, and cost effectiveness of different renewable energy technologies. Undertaken by the local government themselves, the initial analytical process involved the collection of data through surveys of private households, business and the municipality, followed by an evaluation of measures, the results of which finally culminated in an energy action plan. The plan was further developed and implemented by the EEE. From this point onwards, local authority involvement in extended analysis was unnecessary as the EEE conducted further district-wide analyses of its own. The planning, construction and operation of the larger renewable energy installations plants (biomass gasification plants, district heating plants and networks) for example required intensive research and development. These activities were taken over by university and industry partners.

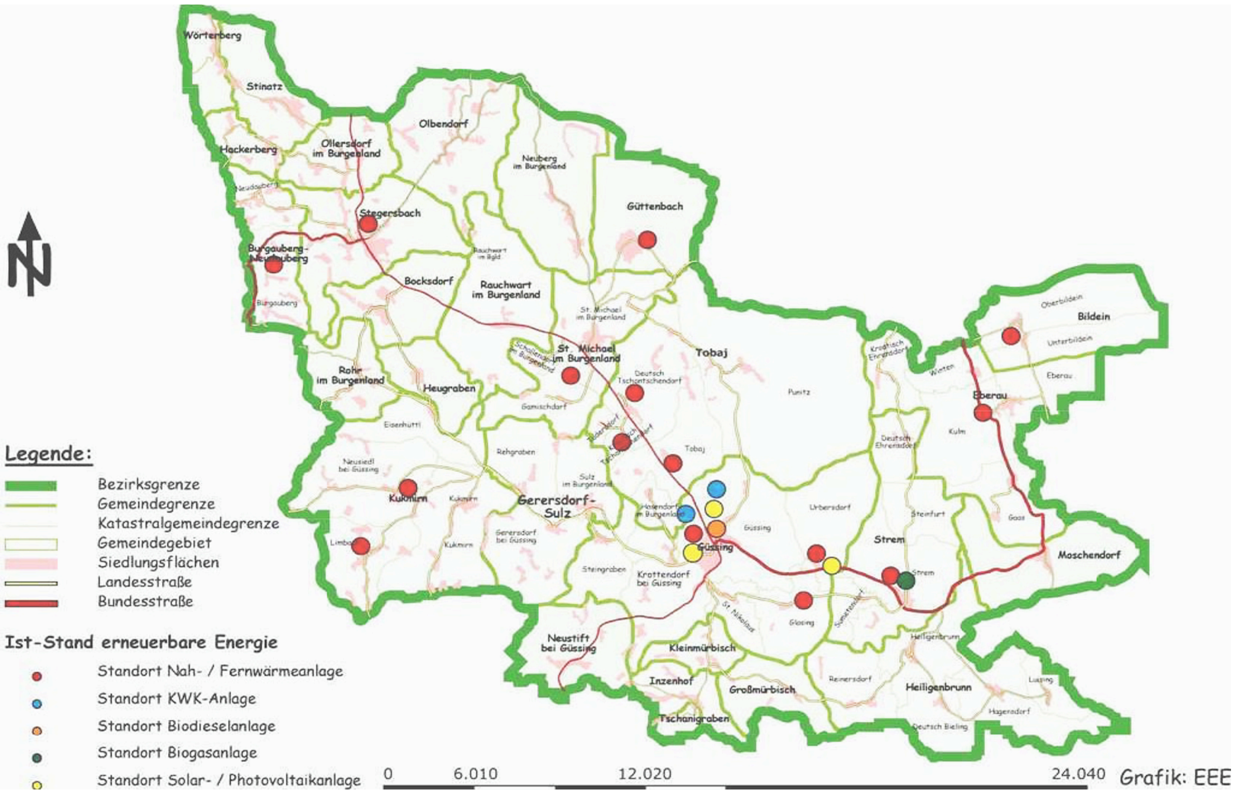
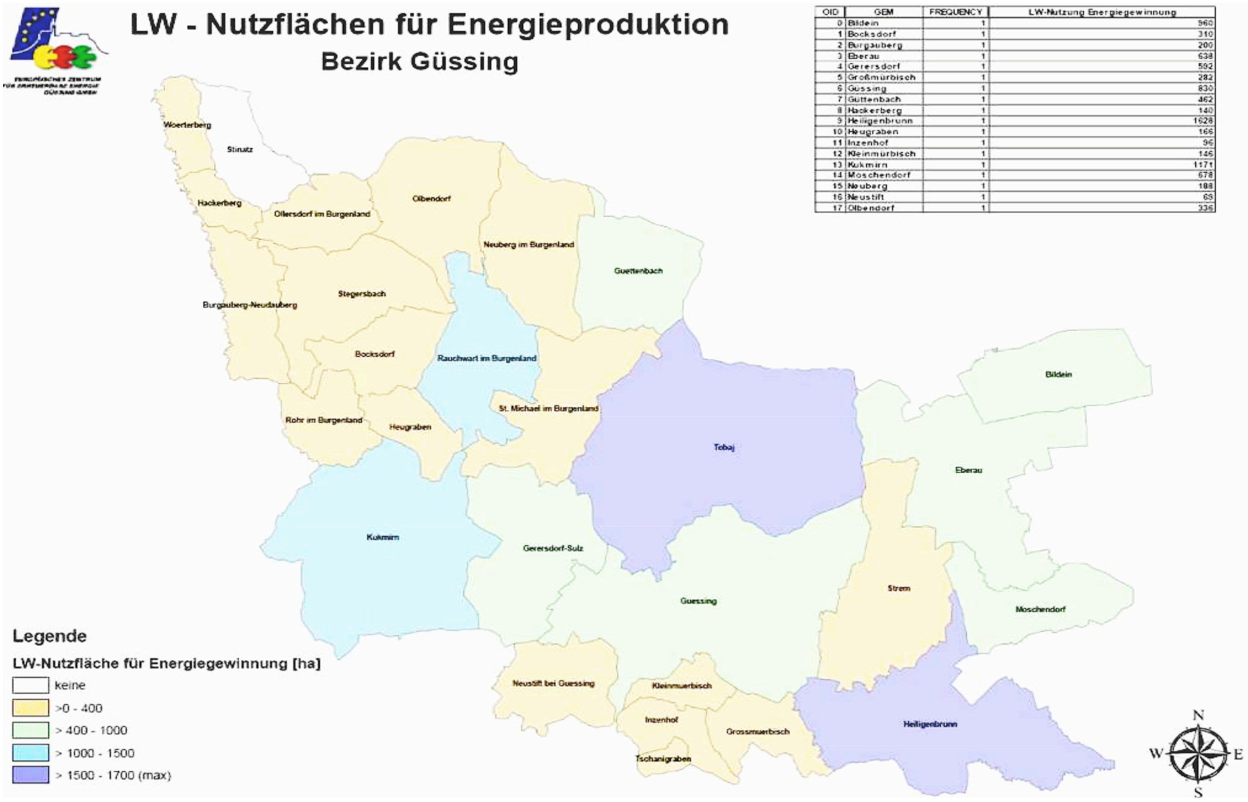


Fig. 95. Plan for renewable energy installations (http:// www.eee-info.net).



OID	GEM	FREQUENCY	LW-Nutzung Energiegewinnung
0	Bildein	1	960
1	Bocksdorf	1	310
2	Burgauberg	1	200
3	Eberau	1	638
4	Gerersdorf	1	592
5	Großmürbisch	1	282
6	Güssing	1	830
7	Güttenbach	1	462
8	Hackerberg	1	140
9	Heiligenbrunn	1	1628
10	Heugraben	1	166
11	Inzenhof	1	96
12	Kleinmürbisch	1	146
13	Kukmirn	1	1171
14	Moschendorf	1	678
15	Neuberg	1	188
16	Neustift	1	69
17	Olbendorf	1	336

Fig. 96. Plan for the district availability of agricultural land for energy production (http://www.eee-info.net).

Samsø

In Samsø, the original 'Renewable Energy Island' plan was developed by PlanEnergi, an independent consultancy company specialising in renewable energy, energy planning and sustainable systems. Prerequisite to the plan was to reduce energy consumption in all heating, electricity and transportation sectors. Informing the plan were analyses conducted by the company as well as earlier energy models conducted by the regional and national governments. By studying the island's annual wind-speed and sunshine-hours, PlanEnergi had found that the island could generate enough energy with alternative resources to fulfil its own energy need. An earlier mapping study conducted by Århus County in 1985, which mapped out the available wind resources in the region, had found that the island possessed huge wind potentials with large areas in the north and south being classified as 'best'. By 1999, the national government had released its own wind resources map for the entire country. Based on these findings, PlanEnergi was able to outline the available resources, provide descriptions of technical and organisational figures, and define a rough but practical schedule to operationalise the 100% plan.

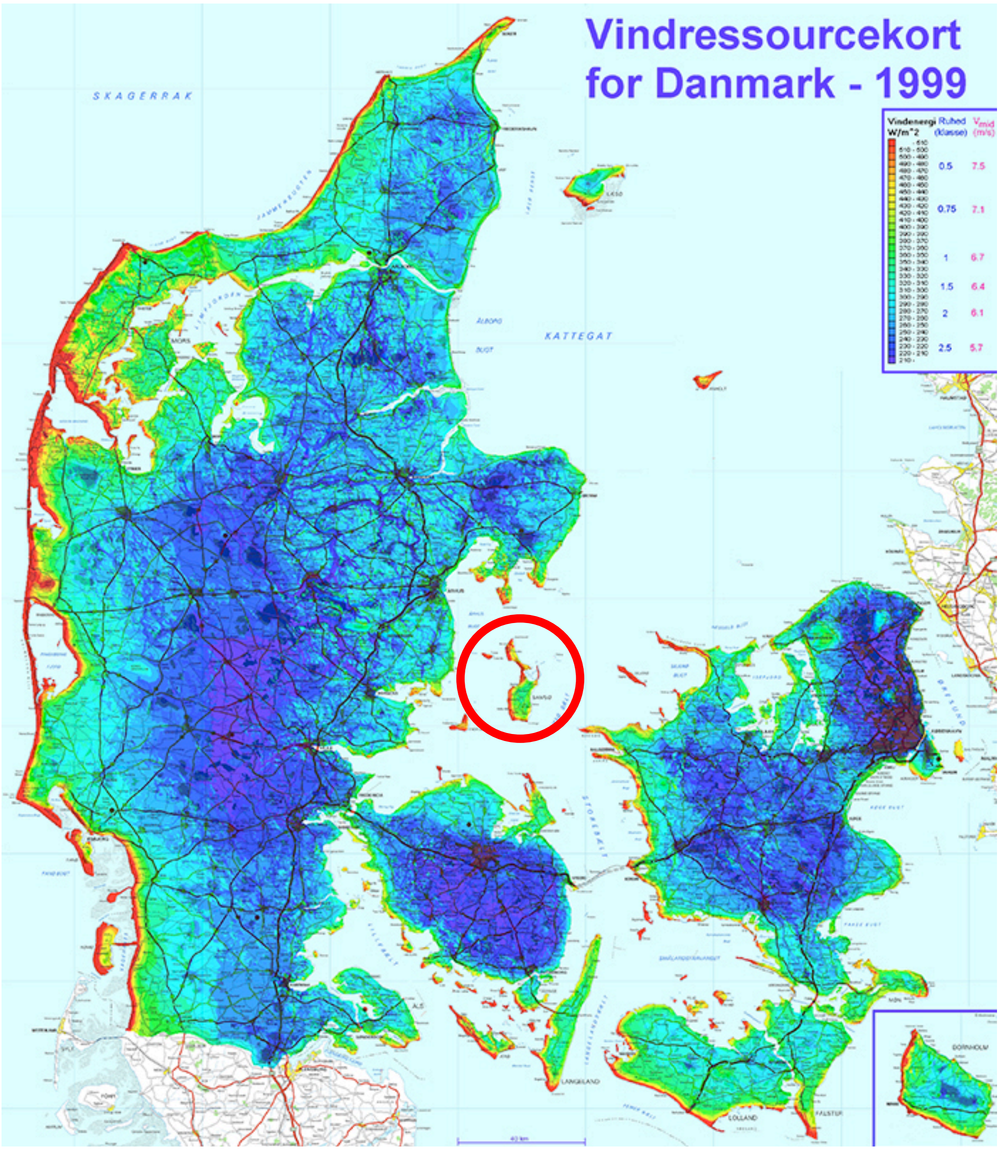


Fig. 97. Plan for wind power resources in Denmark, 1999, with Samsø circled in red (http://www.windatlas.dk).

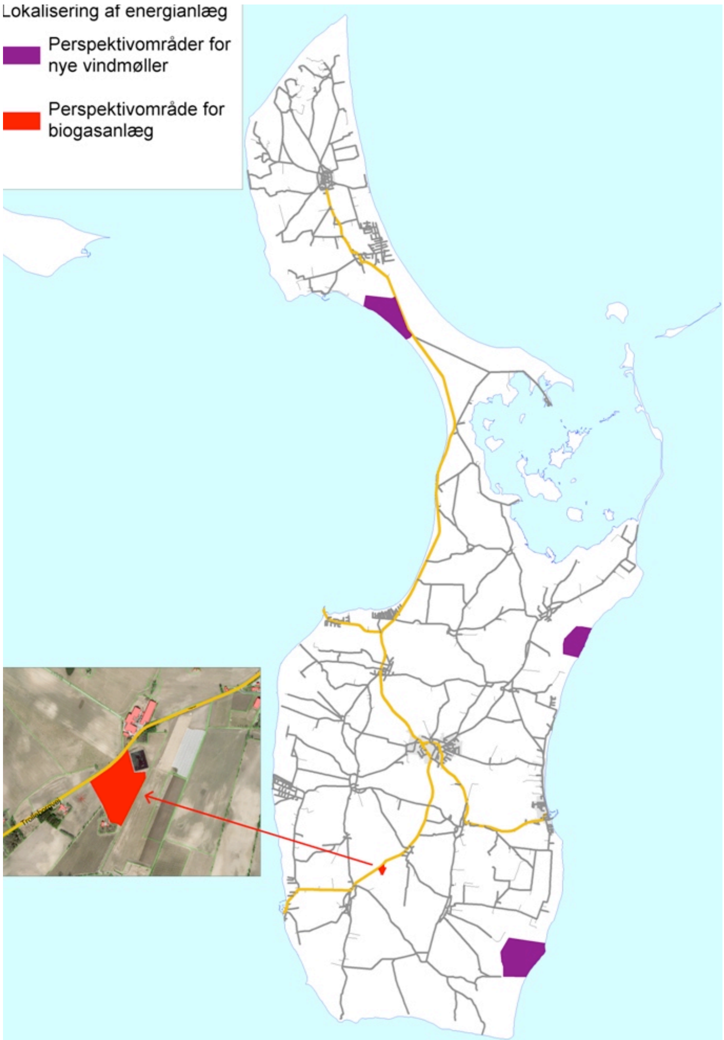


Fig. 98. Plan for future wind and biogas installations in Samsø (http://www.samsoe.dk).

In each of the municipalities, early analysis was carried out either through basic calculations on energy consumption and local energy resources by local government, or through more complex energy modelling, largely undertaken by external energy consultants. In all cases, energy modelling did not so much concern the mapping of energy potentials of different space types like STEM (see Chapter 1 for further detail), but focused on energy-production-geared and value-capturing outcomes. In each case, regional value capture was central to each energy plan. This was generally determined though a type of resource analysis methodology. First, the energy demand and the availability of natural resources were ascertained. Second, an account of the available financial resources and local manpower (social resources) was carried out. Third, the energy supply scenarios and corresponding renewable energy technologies were identified. Fourth, the emissions reduction potentials were calculated. Lastly, cost/benefit analyses to find the appropriate financing model were performed. As a result of these analyses, a set of planning standards and energy targets depending on the renewable energy technology could be formulated for each energy plan, and adapted to the local regulatory conditions.

4.4 Discussion

4.4.1 Response to Research Question 3

Research Question 3 as formulated in Chapter 1 stated:

'In addressing the role of local government, what are the most significant urban development methods employed by authorities who have already achieved energy autonomy?'

For the local authorities who have achieved energy autonomy, the most significant *urban development* methods employed was to analyse local consumption and renewable energy potentials; to conceive a local energy concept especially adapted to local issues; to target local municipal assets for energetic improvements serving as models; to implement small-scale district heating plants and networks connecting public buildings; to develop spatial plans allocating areas for new renewable energy installations and networks; to support localised independent (non-governmental) action; and to seek out research and development networks to operationalise their concepts. All of which are outlined in publicly promoted energy plans, and normalised through the consistent development of projects. Intrinsic to each method is providing the individual, household or business the choice to act upon the information given, from the outset, or at a later stage. For example, knowing how much energy is consumed (and costs) compels the municipality or resident to lessen their use, or knowing how much renewable energy can be generated (and money earned) compels them to construct their own renewable energy system. Similarly, a local energy concept with stipulated measures compels the municipality to publicly commit and implement actions, a 100% energy autonomous public building sets the precedence for households and business owners to transform their own buildings, or an expanded municipal district heating network entices the homeowner to connect to the system in the future even if they cannot afford to do so currently. Meanwhile, a spatial plan, which outlines the energy potentials of areas can induce and inform developers to exploit the energy generation potentials in the retrofit or construction of buildings. If the information, plans and incentives are not transparent, the compulsion for rest of the community to take part, to compete or to even feel the social pressure to act will not occur.

Each of the urban development methods were essentially managed through a central local energy steering group, which either implemented the project directly, or mobilised the relevant community actors (households, businesses, industry, academia) required to implement the project. This committee would always remain part of the local government structure. It could expand to handle more complex coordination and operationalisation functions, or work in parallel but in cooperation with an entity created especially to handle operations - this is separate but remains accountable to the local administration. Such satellite entities can exist as a municipal energy development company or a community energy cooperative. Essential is local government representation on the boards of any satellite entity.

The coordination of relevant actors is a complex process but based on the cases, it appears that the identification, mobilisation and grouping depended on the size and demands of the renewable energy technology or system in question. Since there was usually a range of projects required to pursue energy autonomy, and at different scales, the organisation of actors in different 'combinations and permutations' was essential. One actor may take part in one project or several. Several partners of one project may also handle another energy project or the group be reconfigured with new members to implement other projects. Indeed for local governments, the management of the different ownership and operation styles has been the real challenge. The identification of the right actors was crucial for the administration.

For the three cases, the 100% target was only achievable once the larger renewable installations and networks were implemented, such as the windpower turbines, biomass CHP plants, and district heating networks. Small-scale interventions had only a very small impact in influencing the overall energy balance. The emphasis on smaller systems such as solar thermal or photovoltaics actually receded to serve as supportive, motivational base measures. Because traditional urban development practices have prioritised small-scale renewable energy installations, such as household photovoltaic solar thermal and photovoltaic systems or wood pellet heating systems, shifting the focus to local energy production at a large scale has been another major challenge. For the three municipalities, this was largely achieved through organisational means: Wildpoldsried and Samsø through community energy cooperatives for windpower, and Güssing through research and development networks for biomass cogeneration. The available financial and legal support - EU grants, state subsidies and laws, and the national feed-in tariff system – were all critical to the development of these energy entities.

4.4.2 Case analysis against the six factors based on expert opinion

Based on the analysis of the three municipalities, the six critical factors developed from the Delphi Survey in Chapter 3 can be *re-organised in order of significance* as shown below:

1. Considering the role of local leaders to motivate and to mobilise implementation,
2. Understanding the level of local government awareness of energy autonomy issues and capacities, including the reasons for positions held for or against energy autonomy that follows from a clear clarification of terms in the context of local community and local government,
3. Seeking local government discretion to implement actions that directly pursue the goal of energy autonomy,
4. Creating local energy potentials models by local government,
5. Analysing and utilising the existing local government structure, with augmentation to existing structures through public-private partnerships - and
6. Appreciating and working with the influence of central government on local action in energy projects, with respect to regulations, legislation and standards in a planning, organisational and financial sense.

The six factors

As outlined above, the six factors are ranked in order of importance based on the analysis of the three municipalities. However, the analysis has warranted some modifications with regards to each factor's emphasis:

1. Considering the role of local leaders to motivate and to mobilise implementation

The presence of committed local leaders is undeniable, as the results showed that the social dimension overrode even environmental and economic concerns. The relationships and networks that local leaders were able to establish through public-private partnerships were indispensable for the initiation, development and operation of projects. In all three cases, the two levels – the local individual (micro) and the wider collective (macro) existed in parallel. The individual provided the 'face' to the project and a visible focal figure who understood the cultural dynamics of the local community. The collective provided the technical web of shared responsibility and accountability. The larger scale renewable energy technologies required to achieve energy autonomy: windpower in Wildpoldsried and Samsø, and biomass gasification in Güssing, was reliant on public-private partnerships (macro) instigated and guided by local government leadership (micro). Local leaders played a role in initiating, mobilising but more critically they also pioneered and encouraged innovation. They also demonstrated a conscious commitment to implementing projects in a sequential, steady fashion, in order to ingratiate energy activities as part of daily life, therefore normalising the pursuit towards energy autonomy.

2. Understanding the level of local government awareness of energy autonomy issues and capacities

The need to understand the degree of acceptance and level of knowledge of energy by local government was a priority for the local authorities. Knowing the acceptance of 'energy autonomy' by local government was however not the real issue, but rather whether they first, knew enough of the energy potentials they possessed and second, knew enough to do something about exploiting such potentials though local energy production. Were they aware of the opportunities that existed that could help them to produce their own energy? In Wildpoldsried, mayor Arno Zengerle and farmer Wendelin Einsiedler had long known the economic and environmental benefits of generating local hydropower and biogas, which they used as a basis to develop further energy projects. In Güssing, mayor Peter Vadasz in Güssing took advantage of Austria's ascension to the EU and the subsequent structural funds made available to Güssing as part of the Objective 1 region to develop their energy plants. In Samsø, mayor John Sander Petersen was quick to foresee the economic opportunities entailed in Samsø entering and winning the Renewable Energy Island competition that was organised by the Danish Energy Agency.

Indeed, local governments did not dwell on semantic discussions. However the words *100% self-sufficiency* did figure more consistently than *energy autonomy*, which incidentally did not appear in any of the energy strategies. One could argue that '100%' directly relates to a demonstrable energy generation target that was transparent to all parties. There were no political connotations. It was also a target that was difficult to ideologically deny or oppose. Interestingly setting the goal of energy autonomy or 100% as policy from the outset has not been a determinant for achieving the target. In fact two of the local authorities did not even initially intend to pursue energy autonomy, but rather began as a means to optimise local capacities and address issues such as expanding existing local energy generation practices, promote the sustainable use of local resources such as timber, or address local problems such as unemployment or flooding.

In terms of awareness, all of those responsible for the energy concept and its implementation, mayors and energy commissions, already possessed very strong knowledge on energy matters. Individual political, professional and cultural backgrounds were fortuitously compatible, which served well to drive resolutions to initiate plans and implement projects by mayors and local councillors, and which also crossed the political divide. The notion that local authorities do not think that energy is their business does not hold true in the municipalities since they were all shown to be willing to pursue energy projects. The real concern was not whether they were aware of energy autonomy or whether energy provision can be a formal task of local government, but rather whether they were sufficiently aware of their energy potentials and capacity to generate their own local energy beyond small-scale renewable energy installations.

3. Seeking local government discretion to implement actions that directly pursue the goal of energy autonomy

Seeking local government empowerment to implement actions in energy autonomy has not been essential in any of the three cases. This is simply because each already possessed a fair degree of political freedom, conferred to them by national governments as autonomous entities, free to develop local plans and projects as they see fit but still conforming to national and regional frameworks. For our cases, the pursuit of further powers to carry out projects has not been necessary. The only example of some additional devolvement of power was the case of Samsø. In 2009, the local authority was conferred the power of allocating land for wind power projects, a task that was previously the responsibility of Århus County Office. It provided significant control by the local authority to implement local windpower more swiftly, however it still did not have much bearing on the island reaching its 100% target in renewable electricity. In fact, Samsø had already achieved the goal six years earlier. Although the municipalities did not have to seek further control, this does not mean that seeking empowerment in general is unnecessary. Other towns and cities, which do not enjoy similar rights, may need to develop lobbying strategies for increasing local powers to manage the local energy supply.

4. *Creating local energy potentials models by local government*

There was always some form of basic calculation or modelling undertaken that accounted for local energy consumption, carbon emissions and renewable energy potential, prior to the development of the local energy plan or concept. In each of the cases, simple evaluations by local government were also supplemented by more complex calculations conducted by external energy consultants. In Wildpoldsried, this was provided by EZA, in Güssing, the EEE, and in Samsø, PlanEnergi. Although STEM forms the basis of energy modelling for energy autonomy in this dissertation (see Chapter 1), such comprehensive mapping, or similar, has not been undertaken in any of the cases. In fact, spatially oriented mapping was only conducted in an elementary manner in each case. In Wildpoldsried, thermographic imaging carried out by EZA across the entire village helped detect energy losses from buildings, which prompted improved insulation standards for renovating properties. In Güssing, GIS-based mapping of local forests helped determine the quantity of biomass available for sustainable energy production, which then guided the planning of the district heating systems in Güssing over succeeding years. In Samsø, the analysis of wind power potentials on the island by PlanEnergi was reinforced by earlier wind power mapping studies conducted by Århus County Office in 1985. By 1997, the combined analyses helped define Samsø's municipal zoning for windpower. It should be noted that statistical evaluations in all three municipalities also incorporated economic evaluations, critical to evaluating the different renewable energy technologies options - these financial attributes were not accounted for in STEM.

5. *Analysing and utilising the existing local government structure, with augmentation to existing structures through public-private partnerships*

In all cases, the utilisation of the existing government structure was sufficient to pursue energy autonomy. Indeed, before implementation proceeded, the determination of their own skills and capacity was carried out. This manifested in the form of council discussions to not only develop the energy concept but to determine the necessary personnel, the lines and areas of responsibility, the available planning instruments, and the budgeting of municipal funds. For all three cases, the creation of an energy team or commission to carry and operationalise the concept was always the first act. The team would always include the mayor and individuals responsible for concept initiation. Executive members were always highly regarded individuals from the community. Unlike the traditional practice of embedding energy-related matters within the building and infrastructure departments, the energy team existed as an umbrella entity linked to the mayor's office, informed by each of the existing local government departments. The energy team would ensure that projects were aligned with the goals of the energy plan. They were responsible for setting and upholding the energy benchmark to which all projects were measured against. If any separate entities were created outside of the government in the form of municipal energy companies or community energy cooperatives, these were still accountable to the municipal energy team.

In terms of augmentation, all of the three cases demonstrated the need for an externally created entity, with local councillors as members, to manage and coordinate project implementation and to monitor progress in terms of efficiency, production and general regulatory compliance. Local government representation on the board of external entities was always maintained. In Wildpoldsried, the municipal energy team worked together with its municipal district heating company (Dorfentwicklungs GmbH) and EZA to monitor operations. In Güssing, its energy team worked through the EEE to coordinate the network of renewable energy systems. In Samsø, its energy team collaborated with the Samsø Energy and Environmental Office and Samsø Energy Company to determine the first community members to lead subsequent cooperative workgroups.

The complexity in generating renewable energy from diverse range of sources has warranted not just a range of different technologies, but in parallel, a decentralised form of ownership and organisational arrangements that allows all sectors of the community to participate, and to contribute their expertise in operationalising such technologies. The cases have shown relatively high community acceptance, which when combined with strong political autonomy, created an environment, which made energy autonomy an *inevitability*. If acceptance is already high, community involvement is not actually a prerequisite as shown in Güssing, but if some scepticism exists or municipal capacities are deficient, community engagement is essential as the case in Samsø.

6. Appreciating and working with the influence of central government on local action

Central government influence on local *implementation* was found to be the least significant in all three cases. The feed-in laws and grants for renewable energy have been a boosting incentive but not necessarily a definitive actuator. One may argue that such incentives may not even result in real production if municipalities are not even aware of their energy potentials, if there is low community acceptance for renewable energy, if existing municipal budgets do not permit, or if party politics are hostile to such measures. The subsidies may also have its own limitations: uncertain periods of duration, caps on payments and frequent policy amendments.

Indeed, the cases have shown that it was rather the regional or province-level governments such as the Free State of Bavaria in Germany, the Province of Burgenland in Austria and Arhus County in Denmark, which were the most effective in guiding local government affairs. This was unsurprising given their closer proximity to the municipalities than the federal government in both geographical and legislative terms. Regional government assistance was largely sufficient in the case of Wildpoldsried and Samsø. However in Samsø, the reliance on local enterprise often bypassed even the need for regional assistance. In the case of Güssing and Samsø, EU level grants rather than regional help have been more critical for the implementation of the larger renewable energy plants.

On reflection, the limited involvement in local governance by the national governments has allowed the municipalities to flourish on their own terms and in their own time. As beacons of i*ndirect* influence, the national governments have preferred the promotion of national energy standards for buildings, of which municipalities in time can adopt as statutory policy; the promotion of financial incentives through laws on renewable energy, which municipalities can match or augment; and the design of general policies on sustainability and the environment, which provide a good base for municipalities to build upon and act as it sees fit. Higher-level influence was a positive drive for change, but in each of the cases, the regional government, not the national government, was the entity most likely to assist in the operationalisation of energy autonomy.

4.4.3 Summary

In this chapter, I found that even small and seemingly less powerful communities can control their destiny in climate change governance. The extent of control however depends on the freedom afforded to (and by) its local government, citizens and local industry, enabling them to take charge and organise their own energy ventures, fostered by strong regional legislative frameworks to carry out implementation.

When comparing expert opinion (explored in Chapter 3) to actions taken on-the-ground, the main differences have been: the lack of importance placed by experts on emphasising the role of the mayor as the main drive of energy autonomy; the understanding of local government knowledge and acceptance; the relegation of energy potentials analysis; the downplaying of municipal area planning for renewable energy; the over-emphasis on internal municipal organisational change; the weariness of separate entities for pursuing energy autonomy; and the lack of acknowledgement of regional governance. The importance placed on regulations and incentives by experts was actually superseded by information, education and reform of planning practices, as shown by the cases.

Main differences between surveys and cases

Elevating the mayor's role for energy autonomy

The cases showed that the mayor's role in the energy transition was not to be underestimated, and this figure's presence was essential at most, if not at all, times. Indeed, the local government structure did not have to change but rather the essential reorganisation of priority and responsibility. In the survey, experts were adamant that change was necessary because energy is not traditionally considered the 'business' of local government, nor were they really geared towards envisioning or innovating. The cases revealed that the municipalities did actually consider energy their 'business'. Enormous fuel debts due to imported fossil fuels and slowing local economies had made it a municipal imperative.

Tackling preconceptions

Constant reviews, community surveys and external guidance in energy planning were necessary to educate local councillors and administrators from the outset, necessary to allay fears and clarify any preconceptions and to help them act above and beyond the achievement of minimum energy targets.

The critical turning point for the three cases was the acknowledgement that local renewable energy production can help counter local unemployment, migration, stagnating economy and poor infrastructure. This correlative understanding, rather than of climate change or 'Peak Oil', was critical before any action took place. The governments showed a high degree of understanding and were ready to embrace the technologies, which also confounded the experts' opinion that local governments generally do not have much knowledge on energy matters in the first place. The municipalities were also willing to envision an alternative future for themselves, and were interested in developing frameworks to help the community implement a range of local renewable energy technologies. The municipalities took advantage of their relatively high degree of political autonomy as well as tapping into cultural traditions of community cooperation, independence, self-help, and self-rule, which meant that to refocus the idea of municipal independence to energy independence or in other words energy autonomy, was a natural transition.

One could argue that as European cases, the local authorities were highly developed and educated and therefore had the greatest capacity to achieve energy autonomy. This is not possible in other parts of the world, where governance structures may be fragile; economies are poor and populations less literate. However, I argue that this dissertation does not concern entirely about the end outcome of energy autonomy but the *process* in making energy autonomy a way of life. This is demonstrated in the three cases in their normalisation of energy projects through consistent implementation, the use of social pressure, and 'celebrations' of energetic achievements by the entire community.

Importance of stock-taking

Statistical analyses were essential for municipalities to understand and to convince others about the available resources' the energy, emissions and money saved; the renewable energy technologies required and the finances needed for implementation. The cases clearly showed that energy potentials modelling *did* help boost local improvement efforts. The visualised energy scenarios helped to inform an appropriate energy concept and derive statutory energy maps such as for windpower and district heating. In all cases, external scientific assistance was responsible for this task, affirming expert belief that energy modelling is still beyond the capability of the municipality.

Rediscovering spatial planning

The cases showed that strategic land-use planning either through municipal zoning or local plans was vital in determining the correct positioning and size, the standards of construction, and the environmental impact, of renewable energy installations, prior to implementation. Although experts considered institutional reform of strategic planning practices least significant, the cases showed that this actually took place at an early stage, informed by the broadened awareness of energy issues and potentials. The municipalities realised that the formulation and acceptance of an energy concept, its initiation and implementation required an action plan that guided the spatial demands when installing renewable energy technologies. Although regulations were considered most important for experts, the cases showed that information and education often preceded this.

Minimising internal change

Changes to local government structure were considered necessary by experts to achieve energy autonomy. However, the cases showed that very little change was needed. In all three municipalities, individual councillors and administrators responsible for energy were already in place, but their position was fundamentally elevated from the building and infrastructure departments. Mobilising existing staff, including the mayor, and interested individuals in the community to form an in-house energy group or commission was the default strategy. This was a group, which sat within the existing local government structure. The departments responsible for individual sectors meanwhile remained, albeit expert insistence that cross-sectoral work was imperative.

Embracing externalities

The cases showed that change did not have to take place within the local government structure but it did require *augmentation* in the form of municipal operating entities, (Dorfentwicklung GmbH, the EEE Association and EEE GmbH, and Samsø Energy Company). This negated the fear of 'silos' by some experts while vindicated those who regarded that a separate entity to pursue energy autonomy is essential if existing capacities are found to be insufficient. Indeed, the early stock-taking of capacities was undertaken by all three local authorities. The operating energy entities had to maintain the local energy supply cycle by ensuring strong relations and cooperative agendas with the entire community. They helped maintain learning and working networks that led to rapid development, strong innovation impulses and the broad uptake of fresh ideas on local renewable energy. They also provided constant energy monitoring and feedback to inform local policy. The cases showed that separate bodies could exist separately and distinct from the core structure of the municipality. However they must remain accountable to the municipality by maintaining local government representation on their executive boards.

The significance placed by experts for cooperation was echoed in all three cases, particularly for public-private partnerships (PPP). However, the case of Güssing showed that community involvement was not necessary a prerequisite for energy autonomy as residents played a very limited role. However, it must be noted that general community acceptance for RES in that municipality was already relatively high. Overall, there was no preference shown for either a top-down or bottom-up method for achieving energy autonomy, the selection only depended on the demands of the locality.

Exploiting regional opportunities

Although some experts noted that energy autonomy was best achieved at the regional level, the majority failed to mention the role of regional or provincial (Länder) regulatory frameworks, or even the role of international bodies such as the EU. In all three cases, the regional or provincial and supra-national governments have played a greater role than their national counterparts in supporting the move of municipalities towards energy autonomy.

Spatial observations

With the size of the three municipalities being less than 5000 people, and the median population density of the German 100% renewable energy regions being only 121 per square kilometre (100-ee.de), one questions as to how larger cities could possibly attain the same goal? In this case one has to consider the constituent parts that make up the city.

Indeed, it is easier for smaller communities to pursue energy autonomy since their small size makes it easier for them to reach a common agreement and to match the obviously smaller energy demands. However, if one considers that cities are composed of many smaller individual communities, the strategy for energy autonomy for cities therefore lies in the targeting of each that form the overall city network. The smaller neighbourhoods or wards that make up a city as shown in Table 6 below, can always within their own local administrative powers, decide to transition to energy autonomy. Their identification is essential, thereby enabling city, region or state to further endow them with the capabilities to implement energy projects directly with the community in the pursuit of energy autonomy. Despite being one of 50 local governments that make up the larger Sydney metropolitan area, the City of Sydney in Australia for example has independently created its own decentralised energy masterplan for renewable energy until the year 2030 (City of Sydney, 2013).

Table 6. Examples of administrative neighbourhoods of large cities.

City	Administrative areas
Amsterdam, Netherlands	7 *stadsdelen*
London, United Kingdom	32 boroughs
Tokyo, Japan	23 *ku*
Istanbul, Turkey	39 *mahalle*
Sydney, Australia	50 local governments
Rome, Italy	22 *rioni*
Beijing, China	137 *jiedao*
City of Los Angeles, United States	90 neighbourhood councils

Chapter 5. Governing urban development for local energy autonomy in Liechtenstein

This chapter analyses the governance capacity of the Principality of Liechtenstein to achieve energy autonomy, by comparing the characteristics of its local and national governance in urban development against the energy autonomy factors devised in Chapters 3 and 4. The capacity of governments to govern building and spatial planning independently in order to pursue energy autonomy is not solely discussed in terms of the availability and efficacy of building and planning regulations, but also the socio-political and historical context in which these frameworks operate. A comparative approach following the six local energy autonomy factors structures the overall analysis.

5.1 Context

In 2012, the Renewable Liechtenstein (Erneuerbares Liechstenstein - EL) research project concluded that the Principality can meet all of its energy demands in electricity and heating with 100% locally generated renewable energy by 2085 through the optimisation of energy efficiency and renewable energy generation on roofs and facades (Droege et al., 2012). Even by 2040, the country's dependence on imported non-renewable primary energy sources can be reduced from 90% to 50%. The findings were based on a catalogue of urban space types, categorised according to building function and age, which possess a specific ability to optimise energy efficiency and generate renewable energy for heating and electricity. When the types were mapped across the Principality, and adapted according to various energy scenarios, one of which was the 100% scenario, the types showed that the 100% target for heating and electricity was possible. However this target relies on the implementation of key recommendations and the continuation of existing measures.

Although the Renewable Liechtenstein study has since informed the Liechtenstein government’s Energy Strategy 2020 (Energiestrategie 2020), it has not been adopted as national policy. Instead, the national Strategy proposes a compromised path that maintains 2013 energy use levels through the optimisation of existing energy efficiency and renewable energy production programs. Although the 100% target was included as one of three possible scenarios for the country, it was considered too ambitious for the national government since it appeared to “force” or “impose” the wholesale implementation of renewable energy technologies on the Principality, particularly large-scale installations such as deep geothermal, wind and hydro. This was argued to entail considerable cost to the local economy (energy prices), society (community acceptance), and the environment (landscape intrusion) (Energy Commission, 2012).

Undoubtedly such concerns may be warranted. I argue however that if support for a definitive vision (i.e. 100%) is not promoted at the highest level, there will be no concerted effort to pursue the vision by the rest of society. An unwillingness to pursue a vision due to the avoidance of *possible* problems could stifle future innovation, and in turn the local economy. The fear of potentially negative effects could render a government and a population paralysed, a passivity that inherently leads to maintaining (or returning to) the ‘safer’ Business-As-Usual option. I argue that there is a danger that the Principality could be left behind, as municipalities and counties within the region, for example Wildpoldsried and Tettnang in Germany, and the neighbouring province of Vorarlberg in Austria, have either already achieved 100% or are actively pursuing the target as binding policy.

In this chapter, I therefore address Research Question 4 as outlined in Chapter 1:

Research Question 4 With particular focus on urban planning, how can local governments effect the transformation of existing policies and frameworks in order to pursue energy autonomy?

5.2 Approach

To examine the capacity of Liechtenstein to achieve energy autonomy, the six factors on energy autonomy developed in Chapter 4 were used to analyse local and national government practice in the Principality. Historical and current documentary evidence, which included national and local reports, government minutes, statistics, policy statements and press clippings, interviews and workshops with key local and national government policy-makers as well as discussions with national energy providers, provided the base data for analysis. The information enabled the examination of formal and informal attitudes that have shaped the trajectory of energy planning, the influence of urban development in managing energy consumption and production in the Principality, as well as the socio-economic and political influences. I tracked urban development over time as a consequence of energy use, and examined the appearance of renewable energy in the country, and how its adoption or promotion were impacted by local and national policies on building and urban planning.

The six energy autonomy factors refined in Chapter 4 and used to structure this analysis is as follows:

1. Considering the role of local leaders to motivate and to mobilise implementation,
2. Understanding the level of local government awareness of energy autonomy issues and capacities, including the reasons for positions held for or against energy autonomy that follows from a clarification of terms in the context of local community and government,
3. Seeking local government discretion to implement actions that directly pursue the goal of energy autonomy,
4. Creating local energy potentials models by local government,
5. Analysing and utilising the existing local government structure, with augmentation to existing structures through public-private partnerships – and,
6. Appreciating and working with the influence of central government on local action in energy projects, with respect to regulations, legislation and standards in a planning, organisational and financial sense.

The primary documentation sourced for analysis included:

MAPS
Liechtenstein Geoportal (http://www.gdi.llv.li)
Liechtenstein Power Authority maps
Liechtenstein Gas Supply Company maps
Municipal energy structure plans (all available)
Municipal energy cadastre plans (all available)
National structure plan (Landesrichtplan)
LEGAL INFORMATION
Constitution of the Principality of Liechtenstein (LR 101), 1921
Local Government Act (GemG), 1996
Emissions Regulations for Stationary Heating Industry Facilities
Heating Regulations for Buildings, 1993
Heat Insulation Regulations for Buildings, 1993
Minergie Standards for State Buildings, 2003
Climate Protection Strategy, 2007
Emissions Trading Act (EHG), 2007
CO_2 Act, 2008
Electricity Market Act (EMG), 2002
Energy Ordinance (EnV), 2007
Energy Efficiency Certification of Buildings Act (EnAG), 2007

Energy Efficiency Act (EEG), 2008
Energy Efficiency Ordinance (EEV), 2008
Building Act (BauG), 2008
Building Ordinance (BauV), 2009
Law on Liechtenstein Power Supply Company (LKWG), 2009
Law on Liechtenstein Gas Supply Company Act (LGVG), 1985
Zoning maps of municipalities (Richtplan)
Building regulations of municipalities (Bauordnung)
PROGRAMS AND STRATEGIES
Liechtenstein Energy Strategy 2020
Liechtenstein Energy Concept 2013
Liechtenstein Energy Concept 1988
Liechtenstein Energy Concept 1977
Liechtenstein National Climate Report 2010
Renewable Liechtenstein research project
Agglomeration Program Werdenberg-Liechtenstein
National Transport Policy
Energy City (Energiestadt)
GOVERNMENT INFORMATION
Liechtenstein Office of Personnel
Liechtenstein Office of Statistics
Websites of the Liechtenstein Municipalities
Interviews with key national government government officials
Workshops and surveys with national, local and public utility officials

The Renewable Liechtenstein study has already demonstrated the energy autonomy potential of the Principality (Droege et al., 2012). This chapter therefore does not attempt to recount in detail the statistics in energy efficiency and renewable energy potentials. The focus is instead on the *urban planning capacities* to achieve energy autonomy. It tests the argument that existing frameworks that govern urban development in Liechtenstein are not sufficient to pursue the 100% goal.

Although the dissertation focuses primarily on *local* government practice, the eleven municipalities, which make up Liechtenstein are treated as one collective since they share several common organisational and socio-political attributes, and since the size of the Principality is very small. This dissertation therefore regards the country also as one locality. Since the Renewable Liechtenstein study showed that energy autonomy is most likely achieved at the national level, meaning as one Principality or as one collection of several tiny municipalities, it is fair to say that *local* energy autonomy is achievable but *municipal* energy autonomy is least likely. Since the case studies have shown that cooperation is critical to achieve 100%, the involvement of all municipalities in Liechtenstein is therefore essential to optimise the local collective's energy efficiency and renewable energy potential.

5.3 Background

5.3.1 Geography and landscape

The Principality of Liechtenstein is located between 47°02' and 47°16' north and 9°28' to 9°38' east, within the northern Alpine region of Central Europe. It is 230 metres above sea level. As the sixth-smallest independent country in the world, it covers an area of 160 km^2 in the Rhine Valley. Completely landlocked, it borders Switzerland (from St. Gallen and Graubünden) to the west and south, and Austria (Vorarlberg) to the north. It is flanked to the west by the River Rhine and the Swiss Alpine mountains, and to the east and south by the alpine slopes of the Rätikon.

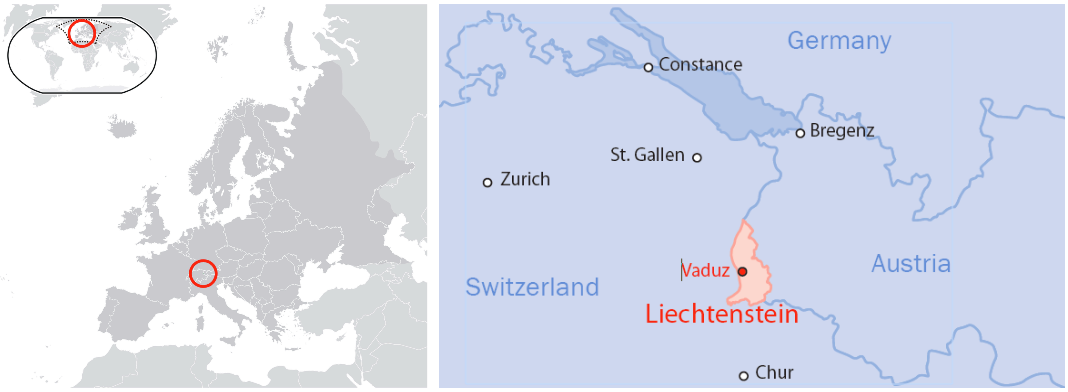


Fig. 99. Location of Liechtenstein (FL, 2009).

The Rhine Valley is situated in a remnant of the glacial Helvetic blankets that moved north through the Alpine Tectonic area during the Mesozoic era. It is characterized by alpine glacio-fluvial geomorphology (shaped by ice and water) and aeolian (wind-formed) landforms (Droege et al., 2012). Its mountains experience seismic movement due to many faults and thrusts. Three natural zones dominate: the valley with sand and gravel soils, and standing and flowing waters; the steep slopes, with their terraces and debris; and the high mountains and high valleys. During the pre-historic area, the Rhine Valley was covered with gravel bars and riparian woodlands. The valley was criss-crossed by the River Rhine, which meandered throughout the valley, prone at particular times of the year to heavy flooding. As a consequence, settlements, roads and areas used for agriculture and grazing hugged the higher slopes of the hillsides on either side of the valley to be safe from the periodic high water (Droege et al., 2012).

Today, settlement continues along this route - the central road axis of the Landstrasse, which extends from the north to south along the edge and base of the eastern slopes of the Principality. Extensive agricultural fields and small farms along the River Rhine dominate in the north, south and west of the country.

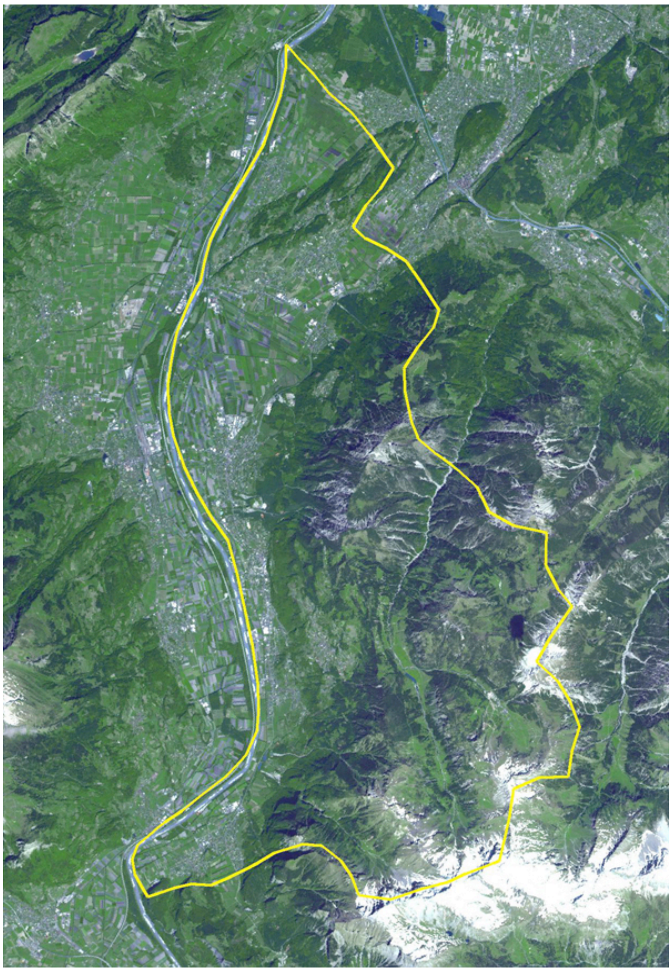


Fig. 100. Landscape structure of Liechtenstein (http://www.jpl.nasa.gov).

5.3.2 Climate and climate change impacts

The climate is warm to mild and strongly influenced by the *Foehn* winds that prolong the vegetation period in the spring and autumn. Rainfall is relatively low, being around 900-1200 mm per year. The mean annual temperature is 10.4 °C. In winter, the temperature seldom falls below -10°C and in summer, it is rarely higher than 28°C (FL, 2012a). It is predicted that by 2050, Liechtenstein and the northern Alps will experience a rise in the average temperature by 1.8°C in winter and 2.7°C in summer (OcCC & ProClim, 2007). Forecasts also predict that by 2050, northern Switzerland (relative to 1990 levels) will experience an increase of precipitation in winter by about 8% and a decrease in summer by about 17% (OcCC & ProClim, 2007).

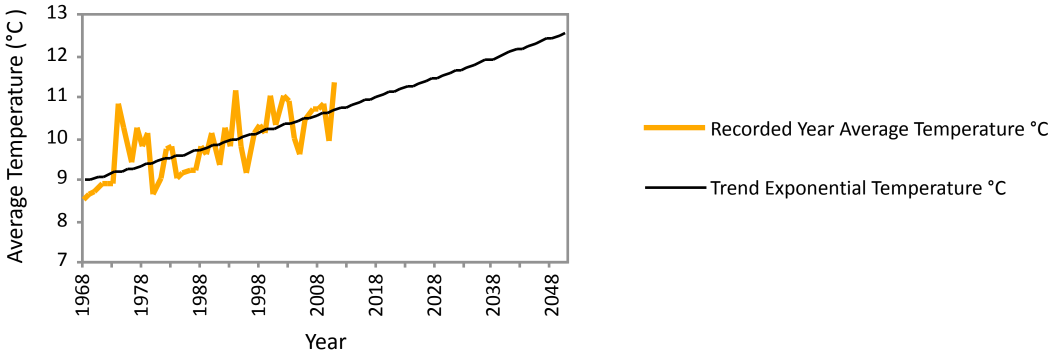


Fig. 101. Projected temperature rise (Based on data by OcCC & ProClim, 2007).

In recent years, research on the effects of global climate warming in the Alpine region have indicated that noticeable changes are to be expected due to increases in CO_2 concentration, rises in air temperature and reductions in permafrost (EEA, 2009). As part of the Alpine area, Liechtenstein will experience the impact of such changes, most particularly on health, biodiversity, soils, tourism and the regional economy. For example, the increasing intensity of heat waves with high ozone concentrations will directly affect the health and wellbeing of communities. Rising temperatures and changing precipitation patterns will cause changes in the composition of forest vegetation and the shifting distribution of Alpine plants towards higher altitudes. The lack of snowfall and periods of snow cover duration combined with the increased intensity of storms will cause more frequent floods and rock- and landslides. There will be more floods in winter but also more droughts in summer. This is a concern especially in the narrow valleys where various protective measures will be required such as rock fall barriers and watercourse corrections. The Alpine tourism sector will be significantly impacted as a result of these climatic and spatial changes. Winter tourism sector will be hit as the snow lines rise higher in altitude. As for the rest of the regional economy, agriculture and forestry will suffer. Droughts will mean the increased probability of damages from insects, pathogens (viruses, bacteria, fungus), fire and storms, making forests particularly vulnerable (Droege et al., 2012). Higher temperatures will also have a damaging effect on crop cultivation in the long term (Fischlin et al., 2003). The predicted affects of a continuing climate change will require both mitigative and adaptive action throughout the Alpine region.

Fig. 102. Forest fires in Balzers, Liechtenstein, 1985 – a climate change impact? (Frick, 2011, p. 11).

5.3.3 Land use and settlement structure

In 2012, Liechtenstein was composed of 41% forest, 33% agricultural land, 15% unproductive areas and only 11% settlement area (FL, 2012a). Settlements have largely been shaped by development zones established for Liechtenstein municipalities from the late 1960s. Prior to this, two typical settlement types dominated the Alpine region: closed and dense village settlements, and individual farms. Traditional building types in the form of the farmhouse and house-farm hybrids were the main building types by the middle of the 19th century (Roos, 2010). Today's development patterns reveal evidence of urban sprawl, incongruous mix of development types and land uses, with residential building types dominating. Two-thirds of residential and mixed development, and a third of the total municipal area (including commercial, industrial, commercial buildings and traffic) is dominated by one- and two-family houses. Only one fifth of the residential and mixed development is made up of multi-family houses (Droege et al., 2012). Table 7 shows the distribution of space types as documented by the Renewable Liechtenstein study.

Table 7. Distribution of space types in Liechtenstein (Droege et al., 2012).

Use		Space type	Ha	%
Mixed use	Settlement core	I	6	0.4
-	Historical buildings	II	0	0.0
-	Multiple family houses with commercial use	III	32	2.1
	Small-scale village structures	IV	37	2.5
-	New building areas	N	(78)	-
Living	Residential high-rises (1950-60s)	VII	2	0.1
-	Multiple family houses without commercial use	VIII	129	8.7
-	One or two family houses	IX	524	35.2
Working	Commercial and industry	X	174	11.7
-	Function buildings	X-Z	89	6.0
Transport	Traffic areas	XI	496	33.3
Open space	Forest (closed forest, scrub forest and woodland)	XII	66621	41.5
-	Agriculture (orchards, vineyards, meadows, pastures and Alpine areas)	XIII	55381	34.5
-	Unproductive (water, unproductive vegetation, areas without vegetation)	XIV - XVI	23851	14.9
Total			16050	100

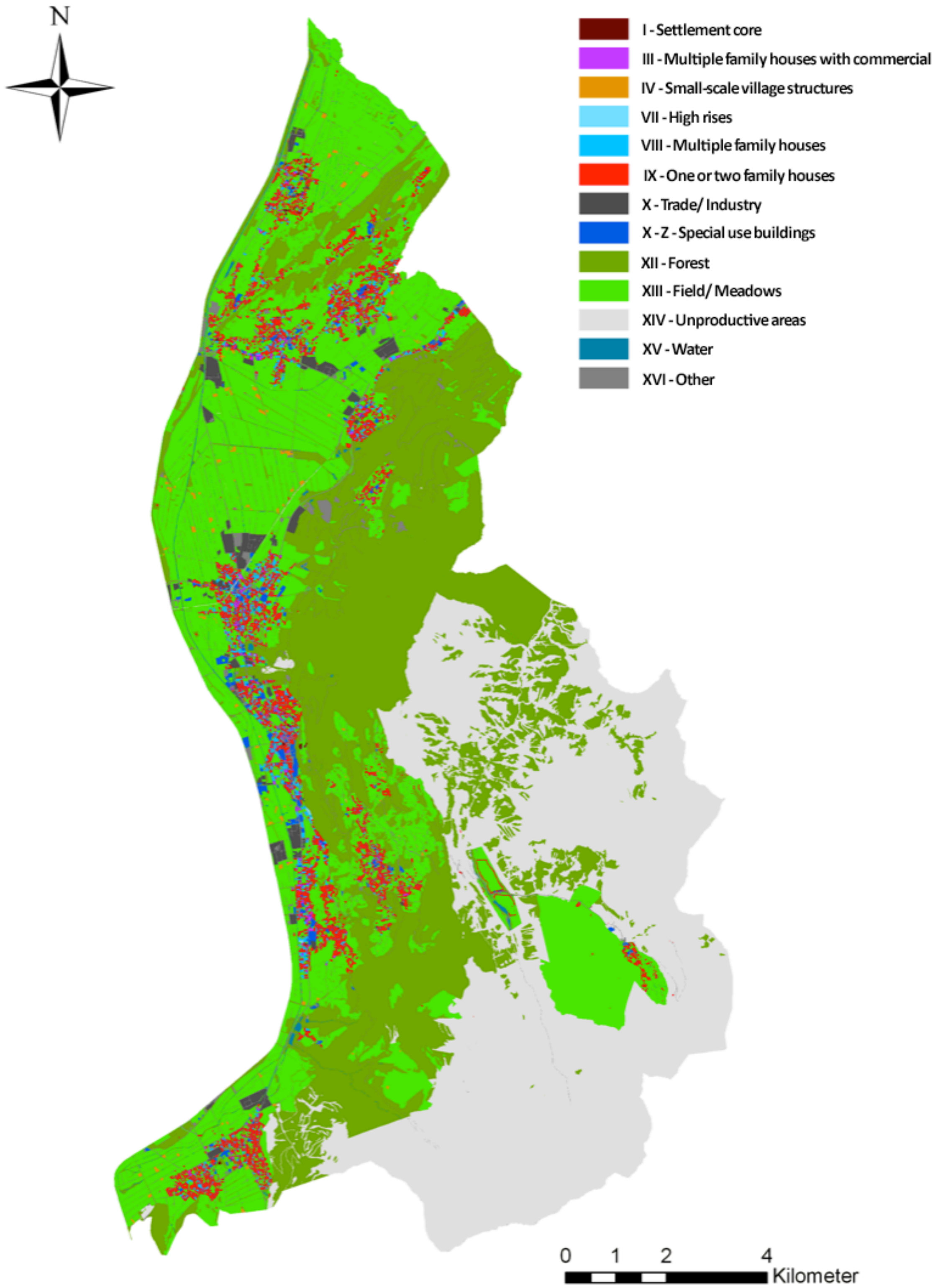


Fig. 103. Liechtenstein space types (Droege et al., 2012).

5.3.4 Economy and employment

Economy

The economy of the Principality is based on general services and industrial production. In 2011, 59.9% of the employed persons worked in the services sector, 39.4% in the manufacturing sector and 0.8% in the agriculture and forestry sector (FL, 2012a). Overall, the national economy includes a diverse mix of numerous small and medium-sized enterprises. The most important branches of the general services economy include the financial and insurance services, legal and tax consultancy as well as trade. In relation to industry, the most important are in the areas of mechanical engineering, electrical machinery, vehicle components, dental technology, food products as well as construction work. In 2010, the gross domestic product (GDP) of Liechtenstein stood at 5.3 billion Swiss francs. The gross national income (GNI) was at 4.5 billion Swiss francs (FL, 2012a). The Liechtenstein GDP derives much of its value from the work done by working personnel living abroad. In 2011, 52% of people at work in Liechtenstein were cross-border commuters from Switzerland, Austria and Germany. The domestic market of Liechtenstein is small, thus most local companies are heavily export-oriented, with much of the goods produced are sold overseas, especially to Switzerland, Germany and the USA. Although Liechtenstein is not member of the European Union (EU), it is member of the European Free Trade Association (EFTA) and part of the European Economic Area (EEA) and Schengen Area.

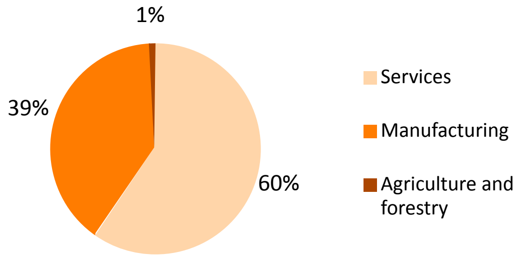


Fig. 104. Economic structure by percentage (Based on data by FL, 2012a).

Employment

By the end of 2011, there were 35253 employed persons. The unemployment rate was 2.5% (of domiciled people in Liechtenstein) (FL, 2012a). More than half of the work force lived abroad. Over two thirds of the work force were foreign citizens. Between 1980 and 2000, it was estimated that the number of jobs had increased considerably more than the rate of population growth (87% compared to 30%). Population growth in Liechtenstein had averaged around 1.3% per year, while the rate of job had increased by 3.2%. Population growth will have a huge impact on land-use in the future. It is predicted that a projected growth of 44000 by 2050 may mean a 21% growth of built-up areas, equalling to an additional 78ha (Droege et al., 2012).

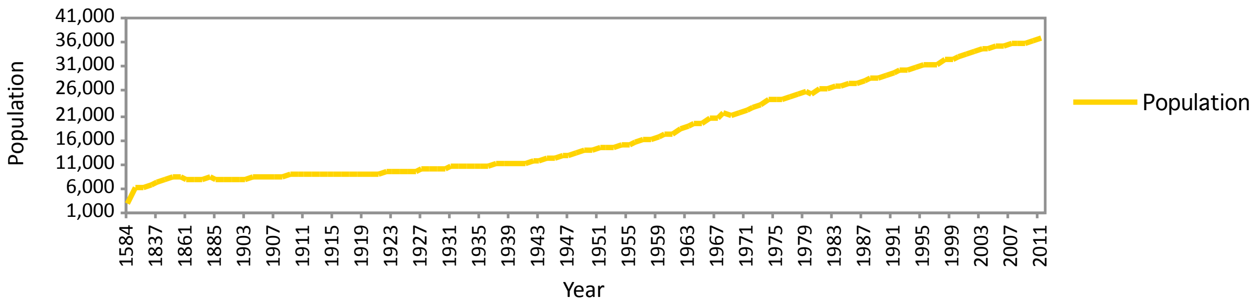


Fig. 105. Population growth between 1584 and 2011 (Based on data by FL, 2010a).

5.3.5 History and government

History

Archaeological excavations have revealed bone and stone tools, pottery shards and traces of buildings in Liechtenstein, ranging from pre-history to the Middle Ages. The oldest evidence of human habitation currently known has been dated at 4700 to 2200 BC (the Neolithic period) in Gutenberg in Balzers, in the south, in Borscht in Schellenberg, and in the Lutzengütle in Gamprin, in the north. It marked a time of a change in human behaviour as people changed from being nomadic to being settled farmers. During the Bronze Age (2200-800 BC), the development of copper and bronze caused changes in settlement structure, as new occupations like the miner or blacksmith lead to a social reorganisation (Roos, 2010). Colonies were larger around areas with high copper deposits, and usually settled for long periods. The Iron Age (800-15 BC) witnessed the replacement of copper and bronze with iron for weapons and working instruments and coins. Iron fixings began appearing in the stonewalls that defended important trading settlements in Schellenberg, Vaduz and Balzers.

When the Romans conquered the region in 15 BC, the area became part of the larger Roman colonial province of Raetia. Despite Celtic influences coming from the west, the inhabitants gradually became known as the Raetians. The Romans settled in the region and established the north-south trading route between Italy and Germany, which traversed the Principality. They established a good network of infrastructure and an accepted form of estate arrangement. The Villa Rusticae typology was adopted for agricultural farms, which were located near water access points and main streets, with many early wooden square buildings replaced by stone buildings (Roos, 2010).

With the fall of the Roman Empire in the 5th century, the centuries that followed were characterized by diminished prosperity and a low quality of life. The former province of Raetia was now controlled by the East Goths, although the majority of the population were still Raetoromans. When the area became under the reign of Franconia from the 6th century, the Franks ordered the controlled settlement of the Alemmanic people to repopulate the empty settlement areas vacated by the former Roman and Germanic peoples. These Alemmanic rebelled against the stone architecture of the Romans, and returned to the early forms of wooden architecture. Only the nobles and the Church took over the stone architecture of the Romans. This era marked the development of complex house and village structures. Village cores became defined, with every village starting its development near the church and the main street. The type of building constructed was dictated upon the availability of resources. Evidence of medieval settlements has been found near the historical roman street (today's Landstrasse) and region around Schellenberg (Roos, 2010). Over the centuries, the population of the Alemannic and Raetoromanic merged together to form the population existing today. The tradition of wooden building construction continued until the early 20th century.

The foundation of the Principality of Liechtenstein itself was the result of the acquisition of land since the beginning of the 14th century, when in 1342, the county of Vaduz was formed and gained imperial status in 1396. The County had been part of the territorial split of the former Roman province of Raetia in 1152, inherited by the counts of Montfort and Werdenberg, who had control of most part of the valley. The territory changed occupancy several times, until Prince Johann Adam Andreas of Liechtenstein elevated the rules of Liechtenstein to the rank of princes in 1608. By acquiring further land and property – the Lordship of Schellenberg in 1699 and the County of Vaduz in 1712 – the Prince was able to form the Imperial Principality of Liechtenstein in 1719 (FL, 2009).

In 1806, Liechtenstein was acknowledged as a sovereign state when Napoleon abolished the Old German Empire in 1806 and founded the Rhine Confederation. By 1815, Napoleon was defeated at Waterloo and a new European political structure was conferred at the Congress of Vienna. The Principality of Liechtenstein became part of the German Confederation, maintaining its political autonomy ever since. In 1852, a Customs Treaty with Austria-Hungary was completed. In 1861, the first bank was opened. In 1862, a reformist constitution was enacted and the first national newspaper was published. In 1918, the first political parties were established: the Christian-Social People's Party and the Progressive Citizens' Party. Demands for direct democratic mechanisms resulted in a new constitution in 1921 (Constitution of the Principality of Liechtenstein [LR101], 1921). When the Customs Treaty with Austria ended in 1919 following the collapse of the Austrian monarchy, Liechtenstein turned towards Switzerland resulting in a sequence of treaties over the following decades. The most important of these treaties is the Customs Treaty of 1923, which forms the basis for close partnership until this day. In 1938, Prince Franz Josef II to Liechtenstein became the first Reigning Prince to establish his residence in Vaduz Castle. Since then, the acting Prince resides in the Principality of Liechtenstein (FL, 2009).

After the Second World War, Liechtenstein joined the Statute of the International Court of Justice in 1950, the Council of Europe in 1978 and was admitted to the United Nations (UN) in 1990. It became a full member of the European Free Trade Association (EFTA) in 1991 and a member of the European Economic Area (EEA) and the World Trade Organization (WTO) in 1995.

Liechtenstein's close cooperation with Switzerland is driven by the customs and currency treaty between the two countries. Though limited to the transport of goods, the treaty impacts significantly on environmental and fiscal strategies in Liechtenstein, such as the CO_2 Act and indirect taxes, except for environmental taxes and tax incentives. The Treaty stipulates that Switzerland can represent Liechtenstein at international negotiations, but at the same time, Liechtenstein is also free to participate in other conventions and organizations even if Switzerland does not participate. Other cross-border agreements exist in the areas of social security, vocational training and cross-border police cooperation (FL, 2010b).

Similarly, the relationship between Liechtenstein and the European Union (EU) is also very close. Through the European Economic Area (EEA), the States of Liechtenstein, Iceland, and Norway are brought together into a single market of the EU, with rules governing the free movement of goods, persons, services; and capital; and joint competition. Other fields of cooperation include environmental protection, consumer protection, research and development, education, statistics, company law, and social policy. Liechtenstein takes part in the development and implementation of EU programs in these areas. Consequently, several major EU environmental standards are also applied in Liechtenstein (FL, 2010b).

Government

The Principality of Liechtenstein is a hereditary monarchy on a democratic and parliamentary basis. The Prince and the people exercises power according to the rules of the constitution (LR101, 1921). The Prince is the Head of State (HSH Prince Hands-Adam II von und zu Liechtenstein). However, since 15 August 2004, the Hereditary Prince Alois was entrusted to exercise sovereign powers. The Prince may veto laws, call referenda, propose new legislation, and dissolve any minister or parliament (the latter may be subject to a referendum) (FL, 2009).

The Liechtenstein parliament is a 25-member body, led by the Head of Government (Prime Minister) and four government councillors (Ministers). The executive leaders are appointed by the Prince for four years upon the agreement of parliament (FL, 2009). Between 2009-2013, the distribution of seats within Parliament consisted mainly of four political parties: Patriotic Union (VU) (n=12), Progressive Citizen's Party (FBP) (n=11), Free List (FL) (n=1) and Independent (n=1) (http://www.landtagswahlen.li). The leaders head the national government administration, which exercises the executive and supervisory authority over 40 offices and diplomatic missions abroad. About 50 commissions and advisory councils also support the work of the Administration. Further responsibilities of the national administration are transferred to public institutions and foundations (FL, 2009).

There are 11 municipalities in Liechtenstein. The eleven municipalities are Balzers, Triesen, Triesenberg, Vaduz, Schaan, Eschen, Ruggell, Gamprin, Schellenberg, Planken and Mauren. The voters of each community elect a Municipal Council, which is headed by a Mayor who exercises his office full-time or part-time. According to Article 110 of the Liechtenstein Constitution (LR101, 1921), each municipality is conferred with an autonomous scope of authority. The Municipal Council carries out its work independently, managing municipal assets and administering building and planning rules. However all municipal actions must still defer to national government policies and legislation. Citizens may call a referendum against the Municipal Council's decisions (FL, 2010a).

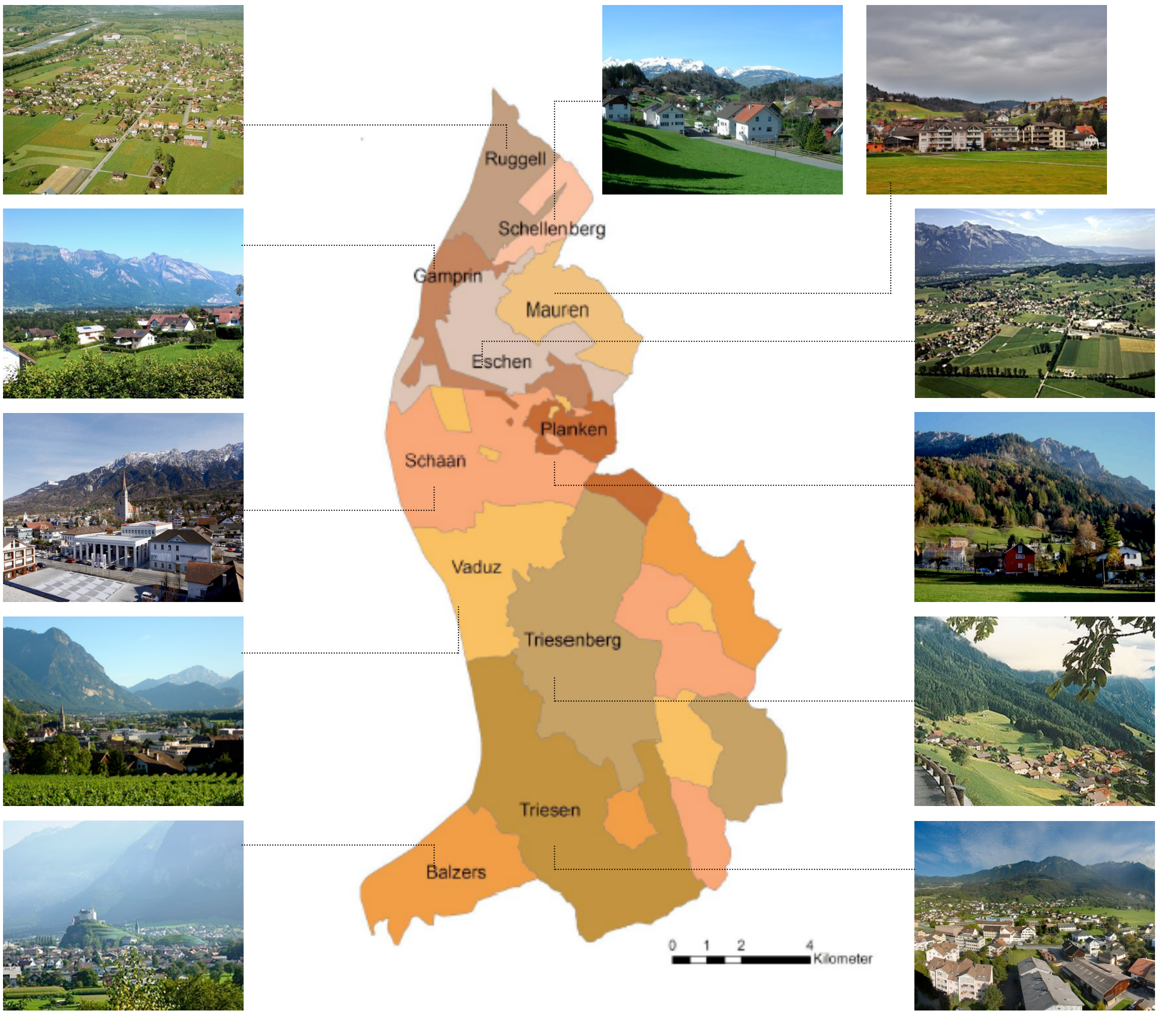


Fig. 106. Municipalities of Liechtenstein (FL, 2009).

Table 8. Liechtenstein municipality statistics (Based on data by FL, 2012a).

Municipality	Area (km^2)	Population	Density (people/ km^2)	Economy	Energy City certified
Vaduz	17.3	5236	303	Services	24.11.2009
Triesen	26.5	4834	182	Services, Industry	08.06.2004
Balzers	19.7	4526	230	Industry, Services	24.11.2009
Triesenberg	29.7	2611	88	Services	20.11.2012
Schaan	26.9	5853	218	Industry, Services	25.09.2007
Planken	5.3	423	80	Services	06.06.2006
Eschen-Nendeln	10.4	4249	409	Industry, Services	19.06.2012
Mauren-Schaanwald	7.5	4012	535	Industry, Services	25.11.2008
Gamprin-Bendern	6.2	1641	265	Industry, Services	20.11.2012
Ruggell	7.4	2057	278	Services, Industry	23.11.2010
Schellenberg	2.6	1033	287	Services	20.11.2012

5.3.6 Energy supply and demand

Liechtenstein is a highly industrialized country with very limited indigenous energy resources. In 2011, the primary energy consumption in the country was 30.3% electricity, 22.5% natural gas, 12.8% fuel oil, 12.2% petrol, 10.5% diesel oil, 6.6% long distance heating, and 4.4% firewood. 0.7% solar, and 0.1% coal and liquid gas (FL, 2012a). The largest portion came from fossil fuels, which were all imported. Around 98% of the imported electricity was nuclear, while 13% was renewable. In relation to the rate of self-sufficiency, which refers to the proportion of energy for heat, electricity and fuels that are met from local renewable sources, this rate was around 10% for heat and 20% for electricity in 2012 (FL, 2012a). Renewable heat is mainly sourced from biomass, heat pumps and solar thermal panels, while renewable electricity is sourced from photovoltaic (PV) panels, small combined heat and power plants, and hydropower. Twelve hydro plants contribute to 19% of the total electrical energy consumption. Self-sufficiency in renewable fuels such as the use of bio-fuels and the replacement of gasoline and diesel-powered cars with electrical ones is negligible in the country.

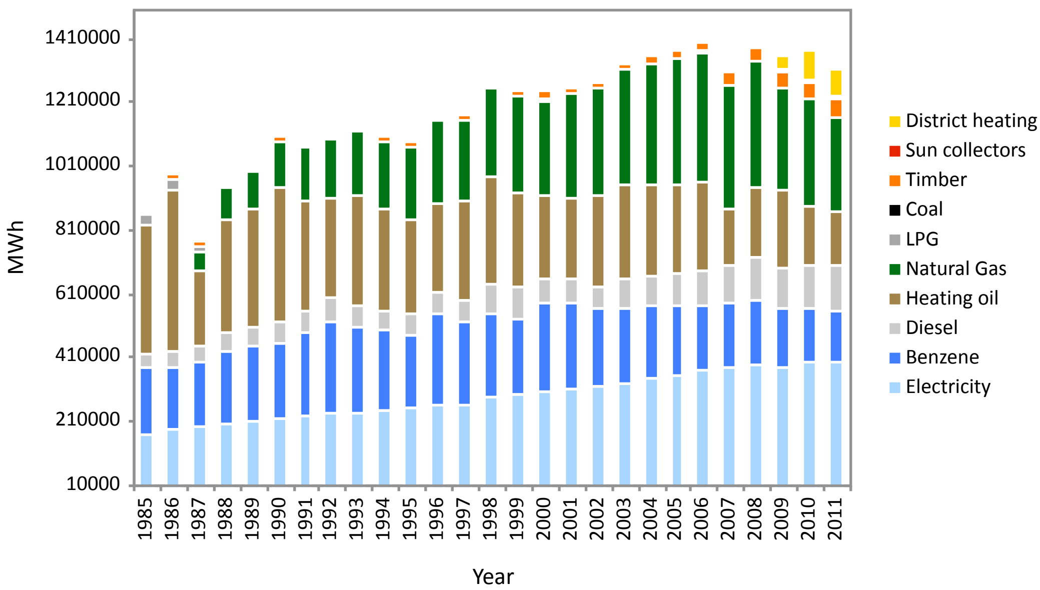


Fig. 107. Primary energy consumption by energy type (MWh) 1985-2011 (Based on data by FL, 2012b).

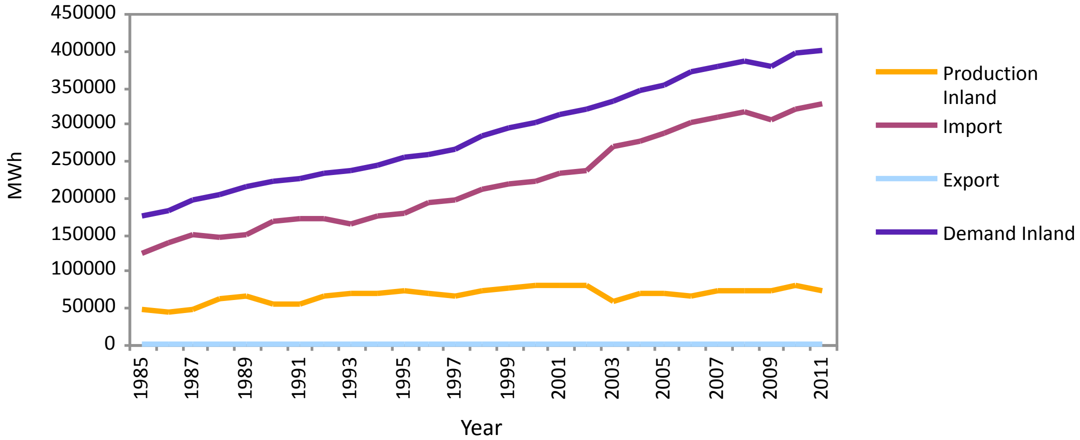


Fig. 108. Electricity production and demand (MWh) 1985-2011 (Based on data by FL, 2012b).

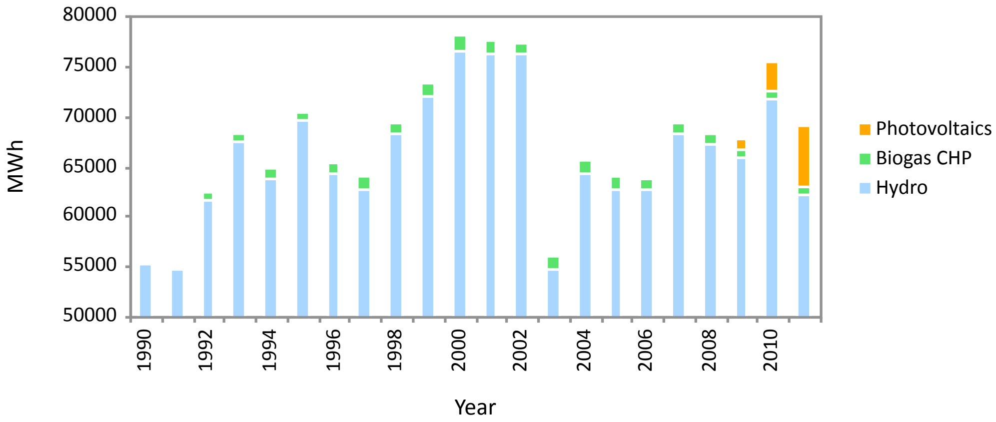


Fig. 109. Domestic electrical energy production (MWh) 1990-2011 (Based on data by FL, 2012b).

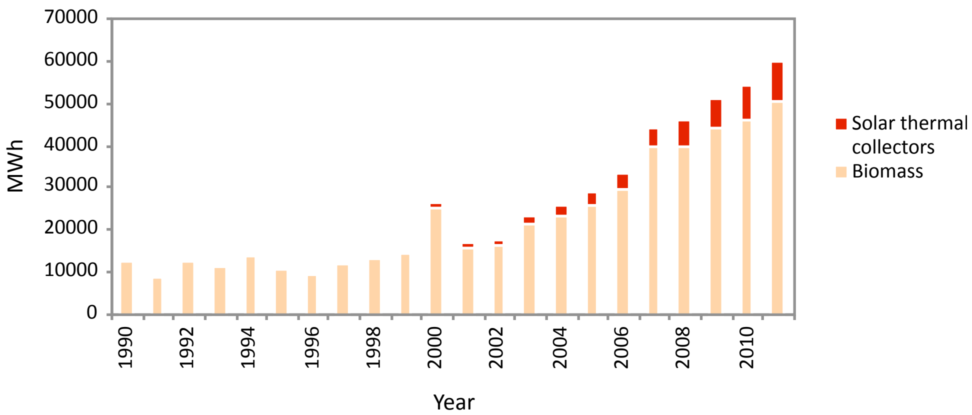


Fig. 110. Domestic heating energy production (MWh) 1990-2011 (Based on data by FL, 2012b).

Projected energy demand, savings and generation

The total final energy demand is expected to increase by 1.55% per year due to economic development (25%), and progressive population growth (13%). Assuming that no measures related to energy are implemented, it is estimated that an extra 185 GWh per year will be required to account for such growth. Power consumption is expected to increase linearly. Without additional measures beyond the existing national energy law and measures (Energy Efficiency Act [EEG], 2008), energy demand by 2020 is expected to increase by 12%. This means that by 2020 energy consumption will increase by 20% or 282 GWh/a, resulting in a total of 1672 GWh/a. However, with the continuation of EEG measures introduced in 2008, energy efficiency improvement of 8% is achievable by 2020. The efficiency potential of all the measures according to the EEG will be around 428 GWh/a.

In 2010, the share of domestic renewable energy sources in the total final energy demand was 9.4%, which is also the rate of self-sufficiency. The aim of the latest national Energy Strategy 2020 is to increase this to 20% by the year 2020, which would amount to 278 GW/h year. This represents an increase of 125% or 164 GWh/a compared to the absolute amount of energy in 2010. The Strategy notes substantial energy generation potentials from renewable resources in coming years: 104 GWh/a from PVs on open areas and roofs, 210 GWh/a from a hydropower plant on the River Rhine, 3.3 GWh/a from windpower and 5 GWh/a of electricity production from geothermal energy. Overall, the share of domestic renewable energy in the total energy demand is expected to increase by 12.5% based on the recommended Strategy measures.

The above statistics were sourced from the Liechtenstein Energy Strategy 2020 (Energy Commission, 2012).

5.3.7 Energy history

Heating supply

Up until 1900, energy supplies for heating in Liechtenstein were rudimentary. Buildings were largely heated with wood and lit by kerosene or gas lamps. Firewood was the basic source of heating and was available in adequate masses. Over time, its use was substituted by coal and domestic fuel oil. By 1959, the consumption of wood was 4838 m^3, and by 1975, it was only 1929 m^3. From 1974 to 1975, there was another increase in consumption, which most likely was a result of the oil crisis in 1973. In recent years, wood has regained importance and by 2008, 14041 m^3 of timber was consumed for heating.

Coal was another important early resource for heating but was quickly replaced during the 1970s with the intensified use of domestic fuel oil. In 1964, the coal consumption was 1400 tonnes, but by 1975 it was only 202 tonnes.

Central oil heating as a heating system had been well established in private houses, industrial, commercial and public buildings by the 1960s. In 1970, 79.8% of all occupied apartments (4533 units) were equipped with oil heating systems, compared to 23.7% (922 units) in 1960. Over a period of 10 years, the heating oil consumption in Liechtenstein almost tripled from 10.4 million kg in 1964 to 27.9 million kg in 1975. The Department for Water Protection (Amt für Gewässerschutz) of Liechtenstein estimated that the oil tank volume in private homes was around 39000 tonnes at the time, a storage capacity that assured supply for 1.5 years.

In the late 60s, a proposal was put forward by the neighbouring province of Vorarlberg in Austria, with the support of the Liechtenstein industry chamber, to lay a natural gas pipeline between Bregenz and Feldkirch. By February 1971, first experts were engaged to examine the economic feasibility of this plan, in particular the provision of natural gas to local industries, but with closer review, it was eventually found that the investment and operating costs for the project would be too high.

It was not long after the advent of the oil crises however, when interest in natural gas picked up once again. The new MOKKA-Pipeline (Monfalcone-Köln-Karlsruhe) had been built to provide natural gas to the Lake Constance area, which soon prompted the East Switzerland Gas Association (Gasverbund Ostschweiz) and the Vorarlberg National Gas Associations (Ferngas-Gesellschaft Vorarlberg) to examine whether a similar natural gas supply for the Rhine Valley to Ems (in Austria) was feasible. Along with the support of the government of Liechtenstein for the proposal, another round of studies finally showed that a partial extension of the gas pipelines, located from Feldkirch to Schaan with a length of 11.5 km, was now possible, especially for bulk consumers such as the industrial companies and some business enterprises. Connections to single-family houses were however unfeasible due to high investment costs in distributing gas to the scattered settlements within the region.

By 1986, Liechtenstein had in place its own natural gas grid, and has since been used for gas heating, combined heat and power units, and filling stations. In 2012, there were three natural gas filling stations in the Principality - Bendern, Schaanwald and Vaduz – distributing natural gas along a 380.3km pipeline network. The municipalities of Planken, Triesenberg, Steg and Malbun were, and to date, not connected to this network.

Another important source of energy for local industries in Liechtenstein has been the thermal incinerator plant, which the Principality and other municipalities within the Alpine Rhine Region are party to. Located across the border from Schaan, Liechtenstein, the plant was opened on 12 March 2008 in Buchs, Switzerland, to provide process heat generated from incinerated waste, over the River Rhine to the Principality. Realized by the Association for Waste Disposal (Verein für Abfallentsorgung - VfA) as a privately financed project, the plant has since supplied two of the biggest energy consumers of the country with process heat: Hilcona AG and the Herbert Ospelt Anstalt. Per year, the steam deliveries are around 125 tonnes, which corresponds to 10 million litres of heating oil, and CO_2 emission reductions of 20000 tonnes.

Electricity supply

Mechanical energy in Liechtenstein was first harnessed from the water wheel to weaving looms or to blacksmith kilns. This form of hydropower soon evolved to generate electricity through small decentralised plants developed by private local industries.

The first electricity generator in Liechtenstein was constructed by local private textile factory Jenny, Spoerry Company in 1883 to light their weaving factory in Vaduz. Another was installed in 1894 for their factory in Triesen. In 1901, the first *public* electric hydropower station was built at the Spoerry Pond in Vaduz, also by the Jenny Spoerry Company, which was then able to supply the entire municipality of Vaduz with power until 1927. The rest of the Principality was electrified when the Feldkirch Municipal Utility (Stadtwerke Feldkirch) first began supplying the communities of Schaanwald and Mauren with electricity in 1906, followed by the municipality of Eschen in 1911. New supply agreements with the utility then saw new local distribution systems in the municipalities of Schaan, Planken, Triesenberg, Balzers Schellenberg, Ruggell and Gamprin. The electricity distribution systems were nationalised on 28 July 1921, when the Jenny Spoerry Company sold the community's power supply system in Triesen to the country. This was followed by the foundation of the state owned company Lawena National Utility (Landeswerk Lawena) in 1923 to take over the entire electricity distribution network. On 6 January 1927, the Lawena hydroelectric power station began supplying electricity to the hillside municipality of Triesenberg for the first time. On 11 January that same year, Mäls, Balzers, Triesendorf, Triesen Oberdorf and Mühle Vaduz were all connected to this network, followed by Schaan and Planken four days later. It was only years later in 1951 when the area of Malbun in Triesenberg joined the network.

During the Second World War, power supplies in Liechtenstein had grown increasingly inadequate. By 1942, power use had risen by 35% in one year, and there were several water shortages. The company Jenny, Spoerry & Cie had begun relying on machine efficiencies to handle the shortage of electricity, while another large company in Eschen, Press- und Stanzwerk AG had promised to take over the electric power supply in case of an emergency. The national power station in Lawena meanwhile had to be continuously operated under full load. The collective pressure soon forced the decision by the State Parliament (Landtag) to not only enlarge the power station in Samina but also establish the Liechtenstein Power Company (Liechtensteinische Kraftwerke - LKW) on 16 June 1947, as a public institution and legal representative for both the state-owned Lawena power station and the new Samina power station. The Samina power station began operations on 1 December 1949. Excess production of electricity was resolved through a power-exchange agreement with the regional utility Nordostschweizerischen Kraftwerken (NOK) and the power stations Sernf- Niederenbach.

Indeed by 1961, locally generated electricity was no longer able to cover the country's energy demand. Liechtenstein had rapidly transformed from a peasant society to a highly developed industrial and service society, which meant that electricity had to be imported, and not only for short-term shortages. When 35 million kWh of electricity had to be bought additionally in 1969, the open-end deal with the NOK was officially closed.

The extension of the natural gas grid in 1986 made the realization of natural gas operated combined heat and power units (CHP) in the country possible. The first natural gas CHP unit was built in Triesen in 1990 and began primarily to feed power into the public grid during the winter months. Similarly, the new Riethof biogas plant began contributing to this system, as well as the larger sewage treatment plant ARA Bendern, which began generating electrical energy from the incurring sewage gas.

Renewable energy sources

As noted earlier, Liechtenstein has been historically reliant on hydropower first as a mechanical energy source, which drove the many textile mills, and later as a vital source for electricity. Since 1862, eleven hydropower stations had been established, with several projects for new stations on the River Rhine proposed since the 1960s. Table 9 traces the development of hydropower in Liechtenstein:

Table 9. Hydropower development in chronological order (Adapted from Roos, 2010).

Power station	Location	Year	Ownership	Notes
Mühleholzquelle	Vaduz	1862	Textile company Spoerry Jenny	Originally used for mechanical energy. Generated electricity in 1883 to light factory building. Rebuilt in 1955. LKW took over the plant in the late 90s.
Letzana	Triesen	1870	Spoerry Jenny	Generated electricity in 1894 to light factory building. LKW took over the plant in the late 90s. Rebuilt in 2002.
Lawena	Triesen	1919	State	System automated and controlled remotely in 1952. Rebuilt and extended between 1985-1988.
Samina	Vaduz	1947	State	Biggest in Liechtenstein. First modern pump storage plant.
Alpine Rhine	Rhine River	1960	Unbuilt	Study commission by NOK, the cantons of St. Gallen and Graubünden and the Principality of Liechtenstein on 14 October 1960 and prepared by Hydraulik AG Zürich found that the plant would cost CHF 260 million, resulting in 22 raps/kWh (compared to 8.7 raps) in 1974.
Five dams on the Rhine	Rhine River between Balzers and Ruggell	1981	Unbuilt	Motor-Columbus applied for a license on 5 January 1981 to build the plants. It was decided in 1994 that it was not possible due to environmental protection rules.
Canal	Point where canal flows into the Rhine River (Ruggell)	1981	Unbuilt	Triggered by the study by engineering company Sprenger & Steiner. Renaturation measures in 1981 on the canal (in Ruggell) impeded the project. Opposition also by the Liechtenstein Association for Environmental Protection (Liechtensteinische Gesellschaft für Umweltschutz - LGU).
Schlosswald	Vaduz	1994	State	Hydroelectric power station powered by drinking water.
Steia	Nendeln	2000	State	As above
Stieg	Vaduz	2007	State	As above
Maree	Vaduz	2007	State	As above
Wissa Stä	Planken	2008	State	As above
Wasserchoepfquellen	Triesenberg (Malbun)	2010	State	As above
Schaanerquellen	Schaan	2010	State	As above

As for other renewable energy sources (RES), generation, distribution and uptake in Liechtenstein has been slow. Meeting local energy demands completely on RES has not been a serious consideration for national and local governments since the 1930s.

The first formal mention was in the national Energy Concept of 1977, which stated that Liechtenstein could be self-supplied with only RES (Energy Commission, 1977). Solar energy generation for example could be fully optimised in summer, however its low generation in winter was problematic. Indeed, confidence in solar PV systems in the 1970s was low since these were not yet fully developed. At the time, solar thermal tubes for hot water were the most common use of solar energy. In Liechtenstein, the first solar plant was realised in Bergweiler Oberplanken in 1974, in the form of solar panels placed on the steep mountain slopes for energy generation. By 1980, additional isolated systems had been installed on small holiday homes. Further autonomous systems not connected to the grid were installed on mountain huts of the Alps of Profatscheng, Tuass and Platta. In 1984, solar panels were placed on two bus stops in Vaduz. The first large PV system that was connected to the grid was a plant on the flat roof of an office complex in Vaduz, installed in 1992. In the following year, electricity from PV was included in the national energy statistics for the first time. By 1995, a PV system covering an area of 180 m^2 had been installed on the administration building of the national utility LKW, and a plant on the Sareiserjoch in Triesenberg, with a capacity of 10 kWp and a surface area of 100 m^2 had also been put into operation. EXPO 2000 prompted the installation of a solar power station on the Rheinbrücke (bridge over the River Rhine) in Bendern. By 2006, a PV power station on the roof of the logistic center of Hilti AG in Nendeln was built followed by a PV power station on the roof of the multipurpose building in the municipality of Mauren.

By 2007, 42 PV stations had been set up in the country, and by the following year, the number of stations totalled 58. By the time the national Energy Efficiency Act (EEG, 2008) came into effect in 2009, 515 solar thermal and PV power stations were operating. The number of permissions had doubled compared to the previous year. In 2010, the municipality of Triesen led in the number of PV systems installed, totalling 148 buildings, which equalled more than twice as many plants approved in neighbouring municipality Vaduz, which had only 76 applications.

Besides solar energy, energy from sewage waste and forestry processing were two other important sources of renewable energy in the Principality. The first biogas plant was a facility in Riethof built in 1991 to feed a CHP, which operated until November 2009. A second plant, the ARA Bendern began operations in 2005, supplying heating energy to around 400 private households. The waste heat was also used to heat the digestion plants and the factory building during winter. An agreement between the Liechtenstein National Gas Company (Liechtenstein Gasversorgung - LGV) and the Wastewater Association (Abwasserzweckverband - AZV) in 2008 soon saw the construction of a new larger, biogas processing plant, which then fed biogas into the national natural gas grid. The local forestry industry provides substantial resources to feed several large-scale wood biomass plants country-wide, the energy of which is used predominantly to heat schools and multipurpose buildings. By 2010, there were 17 biomass plants operating.

The use of deep geothermal energy is still in the research phase in Liechtenstein. It was first examined in June 2008 as a pilot study conducted by Geowatt AG. This was followed by a potentials analysis “Clarification for the potential of deep geothermal energy” (Abklärung zum Nutzungspotential der Tiefengeothermie) was carried out by the company DMT in 2010. A seismology test was performed between Triesen and Sennwald for a length of 18 kilometres, and between Buchs and Schaan for a length of 6 kilometres, the results of which showed enormous geothermal potential in the municipality of Schaan. On the other hand, the use of shallow geothermal or ground-source heat pumps is already commonly used throughout the country. These having been promoted since the 1970s starting with installations in 40 individual households. Their support was intensified when the national Department for Environmental Protection (Amt für Umweltschutz) created public online maps in 1988 showing the optimal areas for geothermal probes and thermal groundwater use. Since then, the number of installations in residential, industrial, commercial, and public buildings has grown, and were significantly boosted by the provisions for geothermal energy through the national EEG law.

Windpower is another source of renewable energy yet to be fully exploited in Liechtenstein. First assessments for wind power in Liechtenstein were conducted in 1989 by the NOK in the municipality of Balzers on the mountain ridge of Fläscherberg. It was not until 2008 when the Liechtenstein Solar Association (Liechtenstein Solargenossenschaft) commissioned the company Meteotest to analyze the wind conditions again but in the area of Balzers-Mäls. It was found that one wind turbine with a hub height of 100 metres and a wing length of 41 metres could generate more than 2 GWh of renewable energy. Another study in mid 2009 by the companies SGL and Weatherpark found that a similar size turbine in Triesen-Weite (Hälos) could generate 2.9 GWh. The focus on local wind power drifted until 25 August 2009 when the State government finally adopted a report and application by the LKW on a budget supplement for the participation in the offshore wind park "Ocean Breeze 1" by becoming a shareholder in the SüdWestStrom Windpark GmbH & Co. KG. However by the end of 2012, this participation ended when the acquisition of the offshore windpark by SüdWestStrom was dissolved due to the unpredictable risks found in the process of completing its construction.

Key events in energy policy development

The first national energy concept introduced in 1977 recognised the enormous potential in saving energy through efficiency measures in all sectors of the economy (Energy Commission, 1977), following the lead of the Swiss Energy Concept, which was introduced three years earlier. Intrinsic to the Liechtenstein concept was also the establishment of an advisory energy commission and a national energy statistics database. By the time the next energy concept was released in 1988, the energy commission was in place and a list of recommendations in the areas of information, building, spatial planning and energy supply were outlined. When the Liechtenstein Gas Supply Company (Liechtensteinische Gasversorgung - LGV) was founded in 1985, the use of heating and fuel oil in the country had been significantly reduced.

The turn towards renewable sources of energy began in earnest in the early 1990s, after talks arose about locating a new nuclear power station, and later a coal-fired station in the municipality of Ruggell. This resulted in swift protest by locals and culminated in the rallying of a few concerned individuals to form the Liechtenstein Solar Cooperative (Liechtenstein Solargenossenschaft - SL). By 1992, the Cooperative was in place with the specific aim to show the government that safer and environmentally friendly energy alternatives were possible in the Principality (Franke, 2012). Since then, the Cooperative has implemented a range of renewable energy projects, from local wind power analyses, to the implementation of PV arrays on public buildings and structures. Their work has since helped inform national government policies in energy such as the Principality's feed-in tariff system and the EEG, through analysis and feedback.

When new insulation and heating regulations were passed for all buildings in the Principality in 1993, it marked the beginning of a concerted drive to save energy throughout the country. It was also the year when RES was formally recognised as being part of the Principality's energy mix, and when PV energy was officially accounted in the national energy statistics for the first time.

In 2001, a levy on high carbon-emitting transit vehicles was introduced, and buses were converted from diesel to natural gas for public transport. By 2010, the fleet of the Liechtenstein Bus Association (LBA) consisted of 44 vehicles, whereby 31 vehicles were natural gas driven. The Electricity Market Act in 2002 gave local consumers the freedom to purchase their energy from any energy provider of their choice. Subsidies for example were introduced for electric scooters and electric bicycles.

2004 was a pivotal year in the Principality's career in energy: the government of Liechtenstein had ratified the Kyoto Protocol, Triesen became the first municipality to achieve the Energy City (Energiestadt) label, the national Energy Concept 2013 was conceived, and the national utility LKW introduced the option of purchasing green electricity to consumers, electricity which was sourced from local and imported renewable energy. They also began promoting PV systems to private households, with a generous incentive of 80 raps/kWh for electricity fed into the national grid. Compared to the previous two concepts, Energy Concept 2013 was the first to outline actions that centred on optimising energy efficiency and renewable energy generation, particularly in buildings, financed via a national and local subsidy framework (Energy Commission, 2004). This action was built upon an earlier measure by the national government in 2003 mandating all national buildings to achieve the Swiss Minergie building standard.

Between the years 2008 and 2009, four highly significant energy laws were passed to regulate the framework of Energy Concept and to coordinate building and spatial planning procedures with national energy targets. One of these laws mandated the creation of national Energy Office (Energiefachstelle), which provided local communities, companies and governments advice concerning energy, its technologies and supporting subsidies. Figures 111 and 112 demonstrate the impact that these energy laws have made on the use of wood fuels, solar thermal and solar PVs for heating and electricity production.

The formal promotion of RES can be seen in the national energy maps for shallow geothermal heating and thermal use of groundwater that were created in 2005. This was followed by government-led surveys beginning from 2008 to discover the potential for deep geothermal energy, discussions of which have continued until this day (2013).

When a new steam pipeline was established in 2009 to take waste heat from the waste incinerator in Buchs, Switzerland to two industrial companies in Schaan, Liechtenstein, it resulted in a dramatic decrease in the electric consumption of imported fossil fuels by industry.

By 2012, all of the municipalities of Liechtenstein had attained the Energy City label, which subsequently promoted the national government to relabelling the country as the first “Energy City Land” (Energiestadtland). The national Energy Strategy 2020 was also released in that year with over 40 recommended measures for pursuing a scenario based on stabilising energy consumption, and which was contrasted against two alternative scenarios: Trend-As-Usual and 100% energy autonomy. The latter was based on the Renewable Liechtenstein study conducted by the University of Liechtenstein.

It is important to note that the most significant development in Liechtenstein’s energy development in the later years has been the winding down of the feed-in tariff system. From mid 2013, it was replaced by an installation subsidy, and a capacity to sell surplus electricity at market rates.

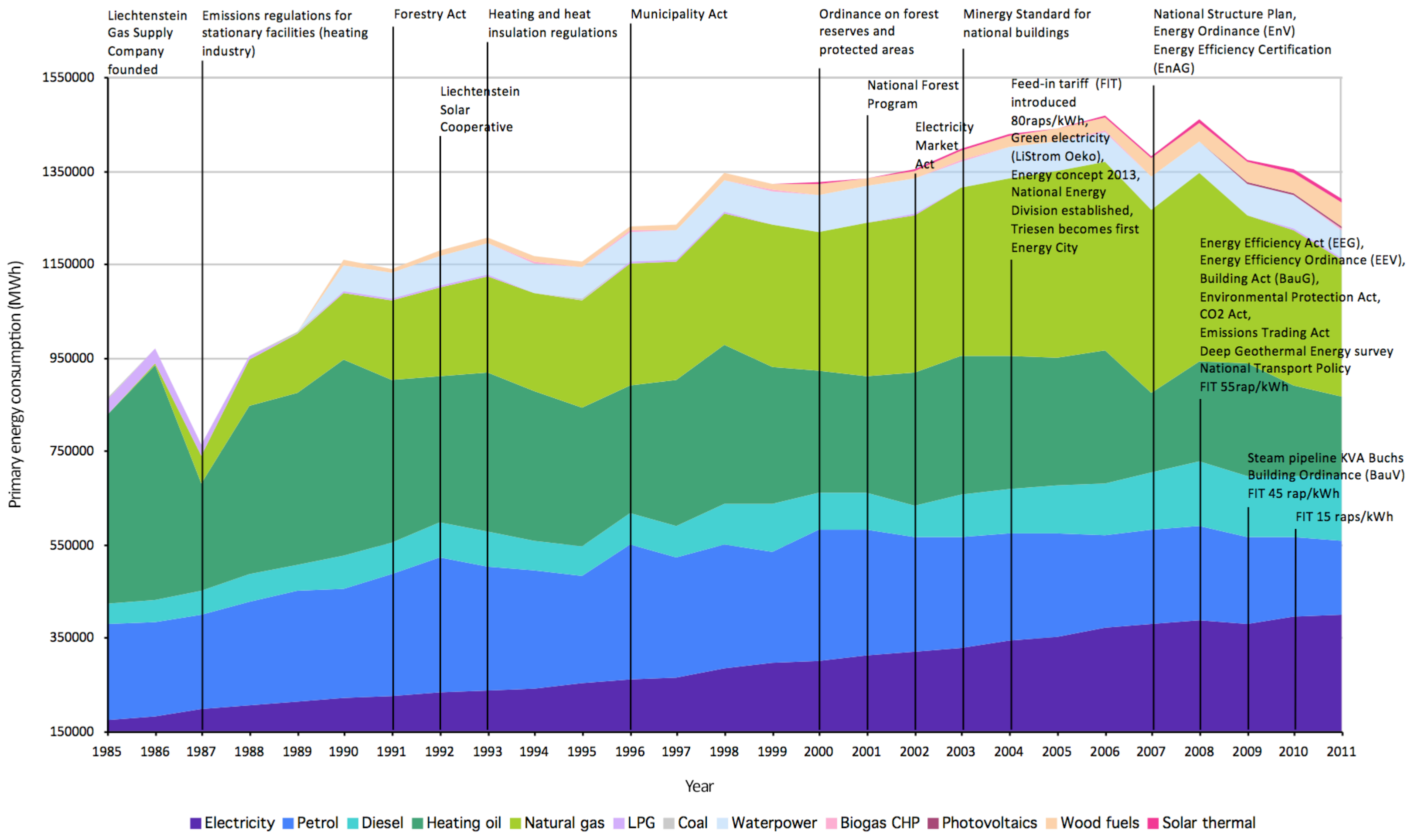


Fig. 111. Primary energy consumption (MWh) 1985-2013 (Based on data by FL, 2012b).

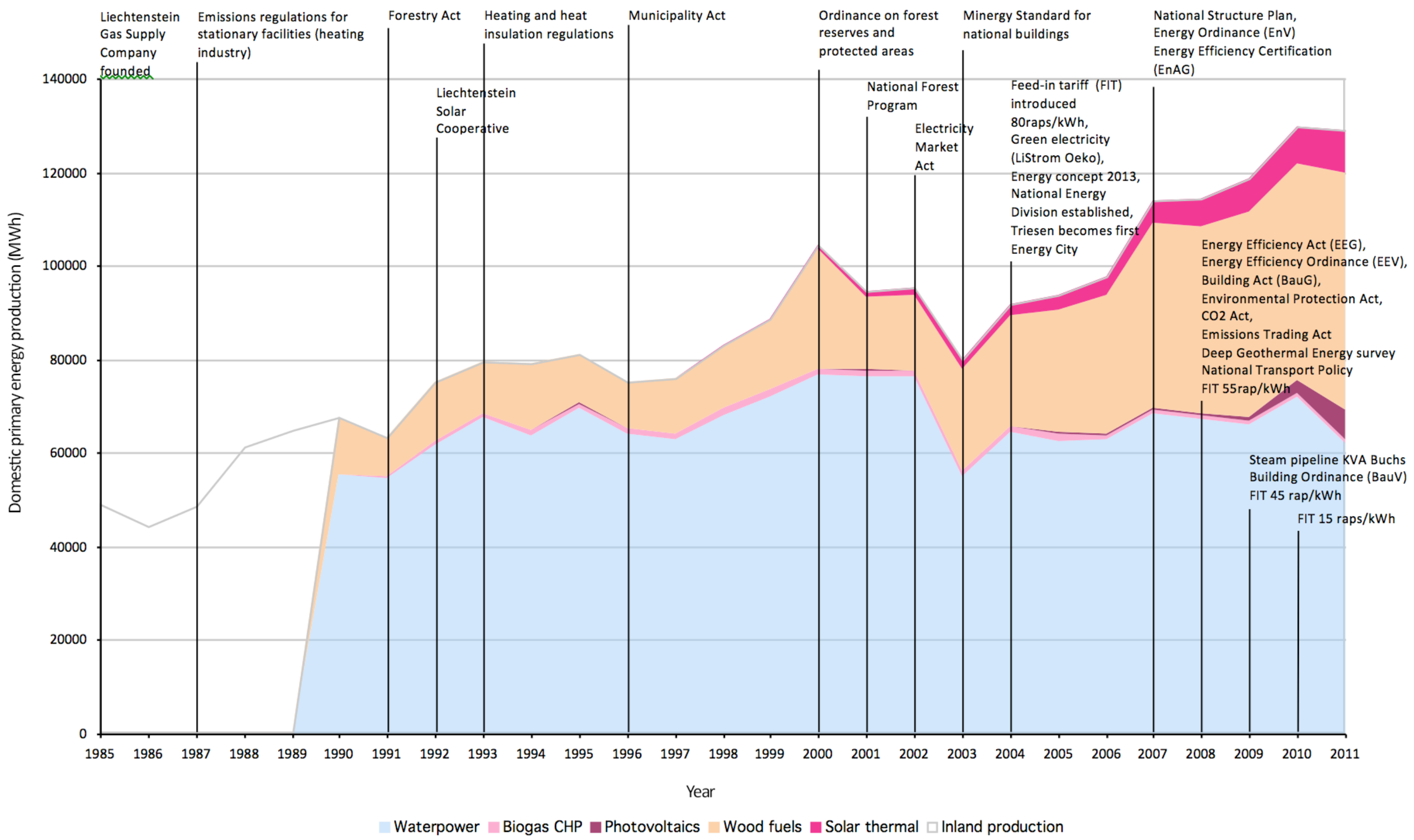


Fig. 112. Domestic primary energy production (MWh) 1985-2013 (Based on data by FL, 2012b).

5.4 Analysis based on the six factors for governing urban development for local energy autonomy

In 2012, the Renewable Liechtenstein study concluded that Liechtenstein could reach 100% self-sufficiency in renewable electricity by 2073 and in the heating sector by 2085 (Droege et al., 2012). The findings were based on projections of future consumption compared against the optimisation of energy efficiency and the generation of renewable energy according to different space types. Limited to statistical calculations and evaluations, the study did not extend to analysing the urban development frameworks required for pursuing such a scenario. The only aspects identified, albeit as recommendations, were the need to address the existing urban and regional planning restrictions (e.g. conservation/ groundwater protection), and to consider the state of infrastructure (e.g. extensions for new district heating networks). Through regulations and subsidies for example, legislature could influence the rate of remediation, achieving the 2% as recommended by the study.

I propose that a significant limitation in Liechtenstein relates to the ability (or inability) of local and national government to adopt a more ambitious vision because its institutions are *entrenched in standard modes of practice that are inflexible to the pursuit of scenarios outside of the norm*. A 100% scenario would require possible new governance arrangements and planning processes geared towards the replacement of existing energy supply structures with renewable energy systems - as evidenced in the Delphi survey investigation as well as the case narrative analysis. By examining the situation in Liechtenstein in relation to the six factors for achieving local energy autonomy through urban development, this section attempts to identify which factors are impeding the pursuit of local energy autonomy. My hypothesis is that local government in Liechtenstein has a greater role to play than previously recognised by the national government, and that both the motivation and innovation in the local energy systems have been restricted by inherited politics, outdated policy frameworks, and established stakeholder priorities.

5.4.1 Factor 1: Local government leadership

Concerted efforts to address energy issues through local government in Liechtenstein began in 2000, when municipalities became aware of and subsequently applied for accreditation to the Energy City (Energiestadt) label, run by EnergieSchweiz, the Swiss national energy efficiency and renewable energy coordinating body and platform operated by the Ministry for Energy (Bundesministerium für Energie). Indeed, the close relationship between Switzerland and Liechtenstein through trade, currency and border agreements has had a huge impact in influencing practice and thinking in Liechtenstein, affecting the content and manner in which environmental and energy policies have been formulated in the Principality. Through the national government administration, the Energy City labelling system has been promoted as an important benchmark for communities and local governments. In this way, the government was able maintain the close ties, keep up-to-date with initiatives implemented in Switzerland and remain competitive with bordering Swiss communities. Swiss influence, in part enshrined in long-established treaties, has dominated Liechtenstein policy, especially in energy matters, more so than the influence of the neighbouring countries of Germany and Austria.

At the end of 2012, all eleven municipalities of Liechtenstein had attained the Energy City label, effectively promoting the Principality to 'Energy City Land'. The mayors of each municipality, with the support of local councillors and external energy consultants, have been integral to the political and promotional drive to maintain the accreditation that takes place through audits carried out every four years. The targets of the Energy City framework, which are essentially based on those of the 2000-Watt Society, form the basis of action for local governments as they steadily work towards the goal. Energy autonomy is not a goal for Energy City. Generally, local governments are free to set their own intermediate targets, and improve on them over time in order to reach the 2000-Watt per person goal. I argue that the moderate parameters in which municipalities are encouraged to operate, lends to a tendency to discount alternate, more visionary targets like energy autonomy.

Based on documentary evidence and interviews, there has been no clear leadership or support for the vision of energy autonomy in Liechtenstein. There is no evidence of mayors or councillors wanting to formally pursue alternatives to the Energy City framework that all municipalities have been entirely dedicated to. Indeed, the framework has been the sole and primary driver of municipal action in energy efficiency and renewable energy in the country.

Liechtenstein municipalities and Energy City

As an indicator system based on six themes, the Energy City initiative is based on pursuing the energy targets of the 2000-Watt Society. This target essentially assumes that municipalities would reduce energy consumption, increase energy efficiency, and raise the use renewable energy to a point that it would take only 2000 Watts to meet the living and working demands of each inhabitant of that municipality. I argue that this concept exhibits two shortcomings: fossil fuels and nuclear energy remains part of the 'energy mix', and energy consumption is targeted indiscriminately, since the ultimate amount consumed should not be an issue if the energy consumed is renewable. The total consumption is preferenced over the *rate of consumption and type of energy consumed*. Through Energy Cities, the Swiss/ Liechtenstein communities are framed to aim at *climate neutrality* in the ICLEI tradition (CCP) or 2000 watt concept – not energy autonomy per se - compared to the German-Austrian-Danish focus of the case studies.

One could argue that the Energy City framework can actually provide intermediate steps towards energy autonomy. In this regard, the measures implemented and planned by the local governments can contribute towards this goal. The benefit of the existing framework is that it allows local government to publicly account for the measures according to six distinct themes: 'Development Planning/Spatial Planning', 'Public Buildings and Facilities', 'Supply and Disposal', 'Mobility', 'Internal Organisation', and 'Communication and Cooperation'. These indicators contribute to the determination of a score (0-100%), which has incentivised local governments to not just improve, but to do more, and all at a higher pace. A re-audit takes place every four years.

A comparison of the Energy City reports of each municipality in Liechtenstein has shown that most measures have commonly succeeded, with only a few being least successful. (See Table 10). Municipal wide energy potentials studies for example, were lacking for most local governments, alongside the absence of municipal traffic plans, although the latter may have been due to the small size of the municipality and the low levels of traffic. About half of the municipalities pursued the Minergie-P rating for all municipal buildings (n=5), which signals a willingness to embrace higher building standards. In relation to supply and disposal, the potential for biogas and re-use of industrial waste heat as part of a local district heating network was recognised, however municipalities have admitted that this still requires further research and development. Spatial planning measures were similarly lacking, most governments tended to resort to basic measures such as maintaining pedestrian paths, cycleway, speed limit zones, and measures related to public transport. Around half focused on the management of parking space, the implementation of a municipal mobility scheme, or the redesign of public space. Overall, traditional, small-scale interventions have been preferred.

With regards to organizational challenges, potential still exists for further cooperation with external local energy partners such as the Liechtenstein Solar Cooperative and the LKW to raise funds, boost knowledge, increase technical expertise, and moreover to implement new energy projects. Indeed, in terms of communication and cooperation, the reports show that collaboration with parties that could potentially help the implementation of larger-scale municipal installations has been very few, even despite the general success in community outreach and promotion. The low priority for cooperation and exchange may be attributed to the Energy City framework, which encourages first and foremost *independent municipal work,* which is reflected on the multiple criteria focusing on municipal activity and the low scores for general cooperation. Although a larger number of points is awarded for special cooperation, collaboration on concrete projects on energy supply systems particularly with regional energy suppliers are not accounted for.

Understaffing is a major issue for local and national governments in Liechtenstein and this is reflected also in the low scores for internal organization in the context of the Energy City criteria. Indeed traditionally in Liechtenstein, human resources responsible for energy have historically been kept very low at both the national and local government levels. At one stage, the national Energy Office was understaffed and running at only 25 percent capacity. At the municipal level, resources have similarly been basic. No person has been given a full-time position on energy. Instead, it has become common practice to impose the task on an official with existing responsibilities in building or infrastructure. Motivation, admitted by one local official, has been minimal; only to change when projects start running well. Consequently, municipalities have turned to outsourcing municipal work on energy.

There is great potential to raise municipal capital by investing in ecological funds. There is also potential in elevating municipal procurement standards, and to implement performance agreements with individual staff members or by departments.

Table 10. Comparison of measures according to the Energy City framework by municipality.

Measures	**Vz**	**Tn**	**Bs**	**Tg**	**Sn**	**Pn**	**En**	**Mn**	**Gn**	**Rl**	**Sg**
Energy City Score (%) (as of 2012)	52	70	54	54	68	69	54	54	55	57	54
Spatial planning											
Mission statement (Leitbild)											
Municipal energy cadastre with indicators (Energiekataster)											
Municipal energy structure plan (Energierichtplan)											
Municipal energy balance with indicators (Energiebilanz)											
Municipal traffic plan (Verkehrrichtsplan)											
Municipal wide energy potentials study											
Municipal buildings and facilities											
Energy accounting											
Renovation strategy											
Energy certificates											
Purchase eco-power											
Building in Minergie-P Standard											
Optimise street lighting											
Supply and disposal											
Solar PV or thermal on public buildings/ structures											
District heating/ or wood chip for municipal buildings											
Small water power (run by LKW)											
Biogas											
Waste water treatment with latest standards											
Establish waste heat potential of industrial area											
Mobility											
Parking space management incl. pricing											
Network of pedestrian paths and bicycle routes											
Speed limit zones											
Mobility management for municipal administration											
Design of public space											
Bus tickets, public transport, taxi service											

Measures	**Vz**	**Tn**	**Bs**	**Tg**	**Sn**	**Pn**	**En**	**Mn**	**Gn**	**Rl**	**Sg**
Internal organization											
Established energy commission	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Activities program	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Budget for municipal work in energy (CHF/capita)	16	-	19	15	8	69	20	50	48	51	36
Special financing models with Solar Cooperative and LKW	Implemented	Implemented	Implemented	Implemented	Not implemented	Implemented	Not implemented	Implemented	Implemented	Implemented	Implemented
Procurement guidelines	Planned	Implemented	Implemented	Implemented	Planned	Planned	Not implemented	Planned	Planned	Planned	Implemented
Investment in ecological funds	Planned	Not implemented	Not implemented	Not implemented	Not implemented	Planned	Not implemented	Not implemented	Not implemented	Not implemented	Not implemented
Performance agreements	Not implemented	Not implemented	Not implemented	Not implemented	Not implemented	Implemented	Not implemented	Implemented	Not implemented	Planned	Implemented
Further education of municipal employees	Implemented	Implemented	Planned	Planned	Implemented	Planned	Implemented	Planned	Implemented	Implemented	Implemented
Communication and cooperation											
Subsidies for energy efficiency and renewable energy	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Free energy advisory services for citizens	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Promotion (eg. Internet, TV, Newspaper, Energy week)	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented

Implemented Planned Not implemented

Mayoral impacts

In Liechtenstein, mayors have rested on the pursuit of the 'Trend-As-Usual' scenario – better than 'Business-As-Usual' but less 'risky' than 'Innovation' - which essentially means small incremental improvements based on previous actions in energy efficiency and renewable energy, with a few planned measures to be implemented in the short-term. Requiring the review of municipal activities every four years, the Energy City framework has set an auditing process, which has been complementary to the local 4-year mayoral and parliamentary election cycles. Understandably, it is a type of *action-based-on-retrospection* that has been preferred since it suits local and national governance periods. It is adaptable to the changes in the local and national economy, political and community acceptance, and advancing RES technologies, whereby energy targets can be amended as the changes take place. One could argue that energy autonomy in contrast requires the placement of a long-term target that would require cross-party support over several election periods, implemented with fluctuating budgets, withstand changing community perception, and updating RES technologies at a substantial cost. An uncertainty, which would be difficult to govern in short periods.

It is therefore unsurprising that there have been no mayors in Liechtenstein who have vocally pushed for alternate visions, targets, or more advanced methods to transform the incumbent energy supply network to a wholly renewable one. As supporters yes, but as leaders, no clear and outwardly demonstrative acts of leadership have been shown. There has been no expression from any of the eleven mayoral offices to pursue any other goal than those defined by their individual Energy City concepts. Even ideological influence from the major political parties in Liechtenstein have not prompted any reaction to the pursuit of energy autonomy or energy self-sufficiency, not even on the basis of a recent coalition statement, which consequently has not filtered back to the local level or prompted mayoral action.

On March 2013, the VU-FBP national government coalition had agreed upon:

> "increasing self-sufficiency in energy, considering the usefulness of implementing Rhine power plants in context of economic and environmental considerations, promoting awareness regarding increased energy efficiency and initiating projects in the area of environmental and climate protection based on international standards" (Translated from FBP Liechtenstein, 2013).

The mayors of Liechtenstein belong to either the VU party (n=6) or the FBP party (n=5). The 'Fatherland Union' or 'Patriotic Union' (Vaterländische Union - VU) was founded in 1936, and the Progressive Citizens' Party (Fortschrittliche Bürgerpartei - FBP) was founded in 1918. They are both Christian political parties, which share similar conservative ideals on energy and the environment.

The abovementioned coalition statement would have little bearing on local government if it was not adopted and driven by the eleven mayors, whose level of education and experience may also influence the degree of understanding and translation of the message to the local context. Certainly their affiliations to the main political parties will have a strong influence, but this is not a clear indicator as to whether this would impact activities at the municipal level. A closer review of the background of mayors reveal that those affiliated with the VU party were most often educated in the fields of finance and economics, while the FBP party members possessed backgrounds tied to the industry and manufacturing sector of the Liechtenstein economy. (See Table 11). None of them possessed formal qualifications in the areas of energy or the environment, except for one - the mayor of Gamprin. The capacity of Liechtenstein mayors to be natural proponents of energy autonomy appears to be lacking, especially when compared to the 100% case studies, whose leaders possessed formal qualifications in energy or the environment.

Table 11. Background of Liechtenstein mayors.

Municipality	Mayor (as of 20.02.2011)	Party	Background	Member of a municipal energy commission
Vaduz	Ewald Ospelt	FBP	Law	Yes
Triesen	Günter Mahl	FBP	Economics	No
Balzers	Arthur Brunhart	VU	History, Anthropology	No
Triesenberg	Hubert Sele	VU	Economics	No
Schaan	Daniel Hilti	VU	Human resources	No (except for Energy City Reaudit 28.09.11)
Planken	Rainer Beck	VU	Finance	No
Eschen-Schaanwald	Günther Kranz	VU	Finance	No
Mauren	Freddy Kaiser	FBP	Tools manufacture	Yes
Gamprin-Bendern	Donath Oehri	VU	Teaching	No
Ruggell	Ernst Büchel	FBP	Industrial drafting	No (except for Energy City Audit 28.09.10)
Schellenberg	Norman Wohlwend	FBP	Industrial	No

Only two mayors (Vaduz and Mauren) are members of their own municipal energy commission, while two, as non-members, have been part of the municipal Energy City audit or re-auditing process (Ruggell and Schaan). This shows a still pervasive acceptance that energy is not a direct responsibility of the mayor. This is underscored by national legislation in the form of the Municipal Ordinance (Gemeindeordnung), which only defines water, sewage, waste management and local planning - not energy - as a municipal responsibility.

But if political affiliations are a critical factor in influencing mayoral decisions, changing priorities in environmental policies at the *national* level can have great impact on local politics. For instance, the pursuit of a more 'radical' vision at the local level may have been stymied by the fact that the coalition government in recent years had withdrawn their statement for supporting the financing of renewable energy production (FBP Liechtenstein, 2013) from the previous coalition government contract (FBP Liechtenstein, 2009). Indeed, some have argued that the FBP-VU coalition was not the most trustworthy when it came to handling the country's energy policy. A small survey conducted in 2007 by the Liechtenstein Solar Cooperative revealed that most of the 330 individuals and small and medium size enterprises (SMEs) in Liechtenstein did not to trust the Coalition to handle energy policy, but instead preferred the Free List Party (Freie Liste), the third most popular political party in the country, to best deal with energy matters (Solargenossenschaft Liechtenstein [SL], 2007). The Free List is a centre-left party founded in 1985 and describes itself as social-democratic and ecologist. Since 1993, it has consistently won 1 to 3 seats in the Liechtenstein parliament. Its climate policy stipulates:

> "defining binding climate targets for 2020 and 2050, the conversion of energy supply to renewable energy, the abandonment of nuclear power and incentives to save energy through a progressive tariff model, prioritise investments to reduce CO_2 emissions towards the purchase of carbon credits abroad, introduce Minergie-P as a base construction standard and employ energy consultants in all communities" (Translated from http://www.freieliste.li).

None of the mayors of Liechtenstein are members of the Free List.

Regional status quo

Although the Liechtenstein Mayors Conference (Konferenz der Gemeindevorsteher) provides the eleven mayors the opportunity to discuss issues and exchange information, documentary evidence and workshop discussions showed that the solidarity shown in the monthly exchanges have had significant impact on the degree of willingness of individual municipalities to pursue changes and implement more advanced projects. Most pertinent has been the explicit agreement between mayors that competition between municipalities should be discouraged, and that individual municipalities should not implement actions that exceed those of its neighbours. This collective agreement was even translated into a proposal urging the national government to cap federal funding for energy efficiency and renewable energy projects so that each municipality would receive equal amounts, avoiding the granting of State subsidies for individualised projects. This would prevent some municipalities gaining more subsidies than others due to their higher number of potentially implementable projects as a consequence of their size and natural resources:

> "With this common subsidy approach, the mayors also want to make sure that no municipality goes beyond 100% of the national subsidy, and avoid that municipalities compete with and go beyond (excel over) one another. All building projects should be equally supported, including single and multiple family homes. National and public institutional buildings (LAK, LKW, LGV, AHV-IV-FAK etc.) should receive no municipal contributions." (Translated from Planken Municipality, 2008, pp.4-5).

Inevitably, the capping of subsidies has meant limiting the number of measures that municipalities would be able to implement. In approving this proposal, the national government has demonstrated an unwillingness to challenge the municipalities to pursue further projects on their own accord. Maintaining regional harmony and status quo has been more important than collective innovation driven by municipal competition.

5.4.2 Factor 2: Local government awareness of energy autonomy issues and capacities

Despite the early history of self-sufficiency in what was a geographically isolated region, this way-of-life has not persisted in Liechtenstein today. In 1947, Liechtenstein began importing energy and fuel from its neighbours to satisfy the growing demands of local industries. Consequently, the accumulated wealth of the Principality grew to such a capacity that it enabled communities to maintain this dependence on importation. Meanwhile, the entry of new industrial establishments benefited by the continual supply. Within only a few decades from the mid to late 20st century, Liechtenstein had developed from a poor agricultural state into a modern society with a diversified economy. The only entity capable enough to handle the energy imports was the Liechtenstein Power Supply Company (Liechtensteinische Kraftwerk – LKW), the national electricity provider.

Energy policy therefore became a *centralised* government responsibility, from monitoring energy flows, controlling prices, to maintaining energy infrastructure. Supply and distribution was the sole responsibility of the LKW, and the municipalities were obliged to source much of its power from the provider. The national Energy Concepts of 1977 and 1988 for instance reflected this acceptance. The concept of energy autonomy did not figure in any of the reports. Renewable energy was only mentioned in the context of small-scale hydropower and wood fuels, and was not considered a critical energy resource. Other forms of renewable energy such as solar, geothermal and wind, were relegated under “Others” with no immediate call for implementation. The recommendation instead was to wait for further research and development into these renewable energy technologies. In relation to local governments, there was no mention of municipal responsibility in energy planning. Instead, the assumption was to leave municipalities with the simple default task of optimising energy efficiency in municipal-owned public infrastructures.

Compared to the energy autonomy cases in the previous chapter, where local traditions in agriculture and forestry have survived and been maintained, similar traditions in Liechtenstein have diminished considerably within the last century. Rapid changes in the economy and demographics have meant that the collective memory of agricultural settlements with their strong focus on self-sufficiency has become irrelevant. The consciousness of energy autonomy has diminished with a rapidly changing economy that has become industrialised and service-oriented. Consequently, the question of energy too has become an industrial question, a technical one, a *scale* of which can only be dealt with at the national level.

However the eleven municipalities of Liechtenstein have over the years become aware of the environmental and economic impact of energy supply and generation, especially in the light of the 1970s oil crises, and the accelerated awareness of global warming as a consequence of continuing use of fossil fuels. Increasingly, municipalities are learning of the social, economic and environmental benefits in managing their own energy supply and production. It strengthens their already sense of political autonomy, as granted by the national administration through the national constitution (LR101, 1921) – an autonomy which gives them freedom to carry out projects and activities that are consistent with central goals. However this freedom has not extended to energy. Its history has shown that since industrialisation took precedence, the municipalities had lost their capacity to wield influence on energy policies and actions. When the Local Government Ordinance (Gemeindeordnung) was passed in 1996, local responsibility was formally restricted to water, sewage, waste management, building and planning. Energy production or energy-related services were not defined as tasks for the mayor or for the local government.

As for energy autonomy, the notion of becoming completely independent from imported fuel (both fossil and nuclear) has never been a part of the institutional lexicon, until recently (Energy Strategy 2020). The fact that the Principality has always been an energy importer was - and still is - commonly accepted and rarely questioned. It is a condition that all local policymakers in Liechtenstein have become accustomed to. Without the experience of an alternate context, curiosity, motivation and innovation in local energy have been kept low over the years. Even with the foundation of the Liechtenstein Solar Cooperative in 1992, the awareness of an energy alternative based on renewable energy sources is still treated as secondary. However, a paradigm shift towards energy autonomy may be taking place. In a local newsletter published in 2013, the municipality of Schaan acknowledged the need to achieve “autonomy… that is in reducing local government dependence from imported energy” (Translated from Schaan Municipality, 2013). This was the first time a local government in the Principality has formally embraced the term - an indication that autonomy is starting to permeate local policy thinking.

Table 12 shows how *self-sufficiency* in the local energy supply has begun to infiltrate municipal discourse in recent years. Although a review of Energy City reports of the 11 municipalities show that energy autonomy has not been a direct target, the *100%* goal has appeared in policy statements with regards to the supply of renewable electricity or heating for municipal buildings and infrastructure. The word *autonomy*, in the context of local energy supply and generation has appeared in only one municipal newsletter.

Table 12. Incidences where self-sufficiency is referred to in municipal energy statements.

Municipality	**Policy statement**
Vaduz	None
Triesen	100% renewable electricity for all public buildings and infrastructure including street lighting (naturemade star)
Balzers	100% renewable heating for all new public buildings
Triesenberg	100% renewable electricity for all public buildings and infrastructure including street lighting
Schaan	‘Autonomy - Dependence on foreign fossil energy is reduced’ – “*Autonomie: Abhängigkeit von fossilen, ausländischen Energieformen wird reduziert”* (Newsletter, Schaan Municipality 05/2013)
Planken	100% renewable electricity for all public buildings and infrastructure including street lighting (naturemade star), 100% renewable heating for all buildings
Eschen-Nendeln	100% renewable electricity for all public buildings (LiStrom Natur = naturemade basic 70% and LiStrom Natur Plus = naturemade star 30%)
Mauren-Schaanwald	None
Gamprin-Bendern	100% renewable electricity for all public buildings (LiStrom Natur = naturemade basic 84% and LiStrom Natur Plus = naturemade star 16%)
Ruggell	100% renewable electricity for all municipal buildings and infrastructure including street lighting
Schellenberg	100% renewable electricity for all public buildings (LiStrom Natur = naturemade basic 90% und LiStrom Natur Plus = naturemade star 10%)

Response to energy autonomy by local and national decision-makers

To further understand the attitudes of national and local decision-makers in Liechtenstein towards energy autonomy, two workshops were conducted at the University of Liechtenstein in 2012, bringing together 17 officials responsible for energy and urban development in the country. The Renewable Liechtenstein study formed the basis of the discussion and was presented at the beginning of the workshops. This was followed by a round table discussion. Each official was free to voice his opinion guided by a set of questions, structured according to five areas in energy autonomy: the Renewable Liechtenstein study, the Space Type Energy Model (STEM), building and planning measures, general governance measures, and organisational measures. The questions were repeated through a take-home questionnaire that was handed out to each participant in order to gain more personal responses.

The results were as follows:

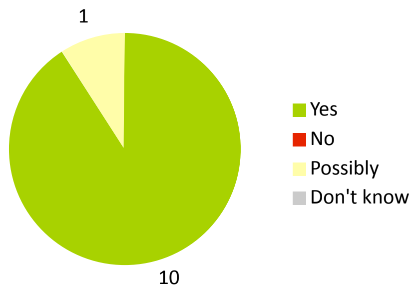


Fig. 113. Number of decision-makers responding to the question: “Are the results of the Renewable Liechtenstein study useful for local and national government in formulating energy policy?”

The majority of experts agreed on the usefulness of the Renewable Liechtenstein study to inform local energy policy decisions. For the national government officials, the study was understood best as a means to motivate and to provoke discussion. However, they also argued that the study would be of most use if accompanied with concrete measures. The municipal representatives and independent energy experts also saw the results being useful for municipalities to decide, define, develop and build on energy goals, but questioned the model’s ability to deal with day-to-day operations and the problems in energy planning that may already exist in the municipality. One municipal official expected that despite the possibilities, municipal implementation would still remain on a modest scale due to limited capacities. Another highlighted that cross-border projects and collaborations would be essential to pursue the proposed vision, while another noted the need for strong political will.

Albeit the support for the study, the majority of the experts expressed concerns with regards to the embedded scientific, environmental and socio-political assumptions, and the time-frames adopted to achieve energy autonomy.

Some assumptions were found to lack sufficient detail, account for local specificities, or acknowledge Liechtenstein’s position within the region. These aspects related in particular to the calculations for fuel requirements for mobility, the accounting of seasonal fluctuations in energy generation, the interdependency on regional energy, and the potential in humus for local carbon sequestration.

First of all, the projected scenario for mobility fuel was not deemed realistic by one municipal official because a detailed database for mobility was not provided. The study was argued to not sufficiently account for actual fuel consumption and driving habits within the country, which is differentiated against the statistics on regional commuters. It is important to note that the Renewable Liechtenstein authors disregarded the energy demands from commuting in order to prevent the need for the local inhabitants to compensate for this. Still, the participants of the workshop noted that a more comprehensive mobility database could have also included information that could influence actual consumer decisions such as data on eco-mobility types, their cost, dealers and available incentives. Another data deficiency noted in the Renewable Liechtenstein study was the calculations for solar energy. By only focusing on an annual average, the potential to exploit summer solar energy surpluses has been neglected. An improved approach noted by some officials would be to integrate a database that differentiates the distribution of solar energy between summer and winter, that accounts for the large energy surpluses or deficits, and that manages the distribution and storage of the energies through a national intelligent grid network and energy storage system. The Renewable Liechtenstein study does not mention any specific measures for energy storage. Another critical condition related to regional energy flows and its impact on the availability and type of energy consumed in Liechtenstein. Many municipal representatives disagreed with the omission of the thermal energy imported from the waste incinerator plant in Buchs, Switzerland. The plant, which supplies a significant amount of heating energy to Liechtenstein since 2009, accounts for 6.6% of total final energy supply in the country (Droege et al., 2012). The majority of the participants were in the opinion that an optimised model should have also allowed a comparison of Liechtenstein's energy situation as part of the regional energy network.

However one measure which was emphatically supported, particularly by the municipal officials, was the use of humus to sequester carbon emissions. Although admittedly not recognised by the Kyoto Protocol as an offsetting method against carbon emissions, many of the workshop participants expressed much interest in pursuing this in their own locality. A consequence of this would be the development of local (or national) humus soil cadastres, with information integrated by area type to see how much savings can be achieved in carbon sequestration.

Energy autonomy as an idea was generally supported by the workshop participants, with most agreeing that it should be a *national* government target on account of the small size of the country. But despite the repeat presentation of the Renewable Liechtenstein study, which showed how the 100% self-sufficiency could be achieved in the long-term, policymakers were still unconvinced that energy autonomy was practically achievable within the boundaries of the Principality. Interestingly, national government officials were more sceptical of the vision compared to the municipal officials. The municipal representatives were more willing to entertain the idea, and to allow the concept of energy autonomy to enter the sphere of local governmental discussion. In contrast, the national administrators questioned why energy or energy autonomy should be tackled, or even be discussed by local governments in the first place. It is interesting to note that there were many who considered the goal a possibility, with a few who did not respond, which indicated that the concept energy autonomy was still not sufficiently understood to allow the officials to make a definitive decision on whether to support or oppose the goal.

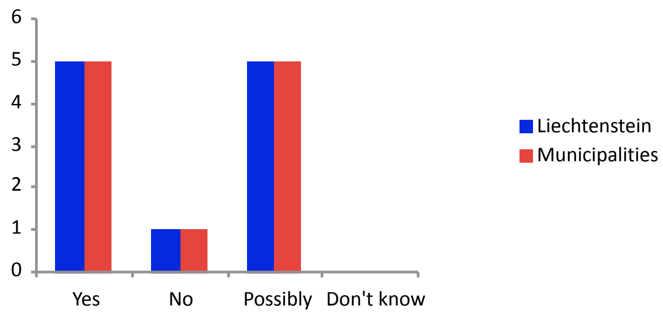


Fig. 114. Number of decision-makers responding to the question: "Should energy autonomy be a goal for…?"

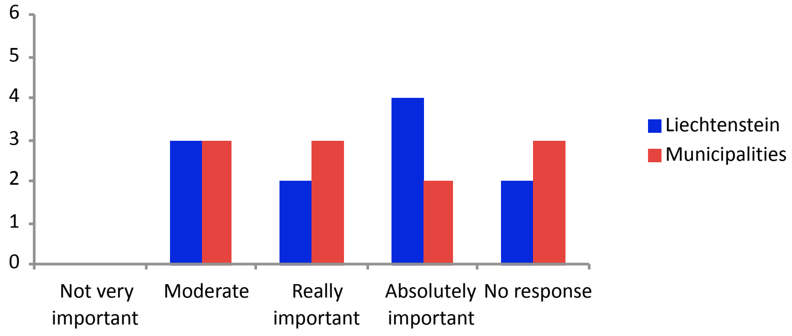


Fig. 115. Number of decision-makers responding to the question: “If yes, how important should the goal be for…?”

Most of the municipal representatives were generally supportive of the energy autonomy goal, stating that it is “the right thing to do”. However based on their collective comments, it all depends on the energy needs of industry, political will, economic efficiency and concrete measures in energy autonomy. Mixed communities and municipalities of residence for example, are more likely to become energy autonomous by 2050, however, industrial municipalities like Gamprin may not. In this regard, it may be more of a question of time frames - not if but when they can achieve energy autonomy, depending on the community type. Industrial Gamprin and Schaan can achieve self-sufficiency but not within the same periods as residential Planken and Balzers.

In comparison to the municipal officials, the national government representatives were more wary of the energy autonomy goal. One considered it “unrealistic … particularly in view of the technical state-of-the-art and current development trends.” They deemed energy autonomy too narrow a topic, likened to a discussion on electric cars when considering solutions to sustainable forms of mobility. Similarly, the energy experts from the national utility shared the same perspective, stating that in view of the small size of the country and the already-in-placed investments in renewable energies abroad that are more cost-efficient, energy self-sufficiency based wholly on renewables within the Principality would not be as cost-effective, nor “desirable”. Indeed, the concept of intra muros applied in the Renewable Liechtenstein study was also criticised to be unworkable in practice. One municipal official from Vaduz noted that pursuing energy autonomy by individual municipalities would actually generate high cost. A better starting point would be to consider the Principality as part of a larger area of the Rhine Valley in order to achieve the goal both logistically and economically. For one national energy expert, energy autonomy should not operate “as a standalone solution but a regional one”, whereby in order to “save costs, the exchange with neighbouring regions is useful.”

One energy expert from the energy consultancy firm Lenum AG (also acting as Energy City consultant to the municipalities) suggested the deployment of the 100% self-sufficiency more as a *communications strategy*, because the implementation of measures recommended by any national strategy will always be uncertain – that is, there is no guarantee which measures will be carried out, particularly over a lengthy period of time. Therefore, it is best to use energy autonomy as a basis to “track a target and to continuously monitor the potential”. And according to one national utility expert, the word “target” itself should be defined rather as a “desirable state”, whereby energy autonomy would “certainly be desirable - but always under the condition that this "condition" can be attained with reasonable effort”. Alternatively, another national government official commented that energy autonomy should be considered more as a vision than a performed state, because it concerns the political process and debate on economic growth and jobs that could eventually lead to energy autonomy.

Several municipal officials were supportive of the energy autonomy goal at both levels of government. According to one official from Gamprin, an ambitious target like energy autonomy is needed because this would be the only way that measures specifically tailored would be initiated. Even if the goal is unlikely to be achieved in the near future, one could still maintain a positive (albeit weak) movement towards it. Another municipal official added that through cooperation between the national government and the municipalities on large energy projects, energy autonomy could easily be achieved. Another argued that placing more trust in the activities of local government would also be essential, asserting that local government action have in many ways already exceeded national targets: "municipalities have moved further ahead than the national government has realised, … with much being achieved in managing local energy supply and demand, … going beyond even the national recommended measures in energy efficiency and renewable energy".

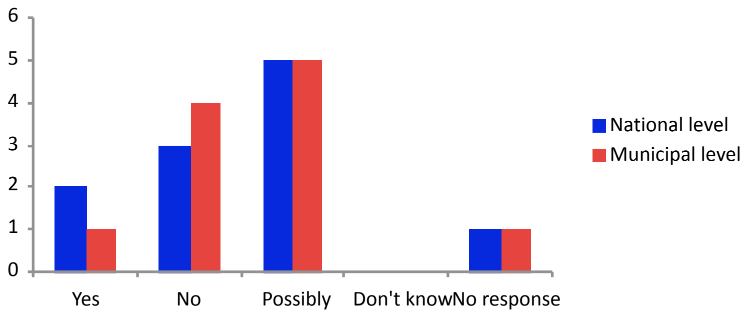


Fig. 116. Number of decision-makers responding to the question: "In your opinion, is energy autonomy practically realisable at the...?"

Many government officials were still uncertain as to whether energy autonomy was realisable at either the national or municipal level, although most acknowledged a strong possibility either way. Based on the comments, factors that could sway the preference was dependent on how drastic the required changes would be to pursue the target, the regional willingness to pursue independence and innovation by necessity, and the individual's sense of self-responsibility, the latter reflected in the comment: "at least … a minimal self-care… [in order] to back one's own space."

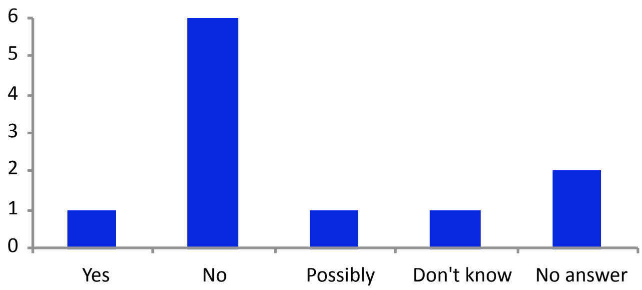


Fig. 117. Number of decision-makers responding to the question: "If you think energy autonomy is possible, do you think that it can be achieved without changes in the national and local organisational system?"

Most officials believed that changes in the national and local organisational system would be needed to achieve energy autonomy. There were however many who were unsure, did not know, or did not respond, which reflected the lack of knowledge on the topic. Further information may have swayed opinions. One LKW official argued that energy autonomy forces more "daring moves and "big steps", which may be possible through legislation and by taking advantage of the simpler, small-scale organizational structures in the country. For one national official, it is more important however to first tackle the socio-political processes such as the instilling the idea of energy autonomy into everyday life and to set an ambitious political agenda based on energy autonomy. The organizational systems can only then be adjusted accordingly.

Changes to the organisational systems according to the comments, should influence the fundamental rethink of the ideal population size, infrastructure, legal system (in the context of social values), and national targets. According to one LKW official: “the path needs to be tackled from two sides. On the one hand, the legal basis must be created (efficiency and sufficiency), and on the other hand, the values in society need to be sharpened on energy and climate sensitivity to create understanding for this route.” One municipal official also noted the role of legislation to better manage domestic energy, to place the objective above all other interests and encourage support by the politicians and the public.

To adjust an organisational system is complex, particularly to suit a target that is only achievable in the long-term, argued one LKW official. In the future, new forms of technologies may be discovered within the next 50 or 70 years, which “illuminates the subject [energy autonomy] from a completely different angle.” According to one national government planning official, such long time horizons will also require addressing the socio-political implications of whether the measures required to be implemented need to correspond to particular time periods. One municipal official adds that any changes moreover would be difficult to implement since it requires strong and sustained political will. And before frameworks are changed, there are other sectors that should be accounted for such as the impact of mobility and industry that was missing from the Renewable Liechtenstein scenario. These are the “real” energetic factors, argued the LKW representative. Several officials generally agreed that in small municipalities, with mainly residential households and with little industry, no changes in organization would be required to pursue energy autonomy. On the other hand, others query as to whether focusing on local and national organization was actually useful in the first place, in that opportunities perhaps lie better in the context of a regional organization.

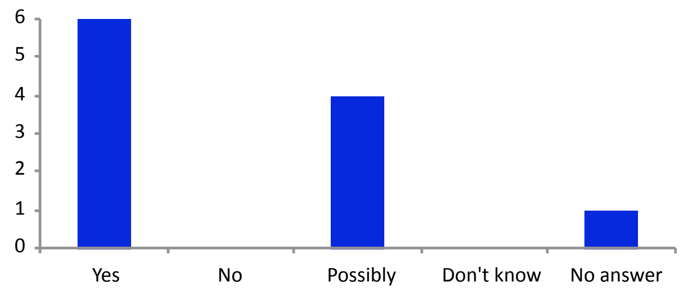


Fig. 118. Number of decision-makers responding to the question: “Are you of the opinion that an interactive model scenario like STEM can drive national or local efforts to improve energy policy?”

Most experts believed that STEM could drive both national and local efforts to improve energy policy. There were however many who were unsure as to its overall impact. Experts highlighted problems with regards to the time periods to achieve energy autonomy, and the ability for local governments to maintain a municipal energy model in order to guide them towards local energy autonomy.

The time frames adopted (e.g. 2050, 2070) for instance, were considered too far-reaching, unfathomable for policy-makers who operate in political cycles of no more than a couple of years (minimum 4 years in Liechtenstein). The maintenance of energy policies that would last fifty or seventy years could not be guaranteed argued some officials. Furthermore, it may be difficult to convince local businesses and industry to adopt measures that focus on long-term profitability of more than 10 years. There may also be radical improvements to RES technologies that would supersede earlier systems in terms of cost-effectiveness. The cost in updating may outweigh the long-term cost in installing and maintaining older systems. Meanwhile, changing community acceptance and transformed economies may also impact the continual pursuit of the goal.

The energy model's use as a dynamic planning tool for local policy-makers was queried by several participants, as substantial effort would be required for municipal councils to develop, integrate and maintain their own local energy model. Additional local energy data to supplement the data already available at the national level would be essential. According to one national utility official, a regular update of the local scenario models would have to take place. Depth of data in relation to spatial types that is geographically anchored would be necessary to allow differentiation between municipalities, as one cannot assume that on average, the municipality has the same structure as the entire country. The model could furthermore help formulate or refine the local energy cadastre, which will not just show the best areas for solar, geothermal, small-scale hydro, biomass installations, but will visibly express the energy efficiency and renewable energy potentials in unit generation and monetary terms, all delineated in a single plan.

A localised STEM could be linked to the existing intelligent grid network, and the information made more transparent and understandable, through increasing the interactivity of the model. Institutions could obtain an image of the potential and thus plan their activities (planning, projects, and investments) accordingly. The optimised local model could become a public online tool, rather than just a decision-making and proprietary planning tool for the municipality. Existing data that was previously too abstract for community use could now be made more legible by visibly categorising the data according to building, area and community type. The integration of relevant energy data in a single website could also lessen the need for the public to consult directly with the municipality.

Despite the potentials described, the range of tasks involved is problematic because existing local administrations do not have the capacity to acquire, process and interpret such data. The improvement of a model integrated with a range of data types requires strong budgetary, technical and administrative capacities, a potential that can only be made possible with national government support. Individual local energy models will be a cost- and time-consuming venture particularly since Energy City is already a big effort for the municipalities in Liechtenstein. One municipal official noted that local governments would always "have to ask themselves where to invest best [in order] to get back as much as possible."

To determine which specific spatial planning measures would be most useful for the pursuit of energy autonomy by the local governments, a list of measures related to energy efficiency and renewable energy were posed to the 17 decision-makers.

How could such models for community planning, particularly for physical planning, be useful?

When asked how STEM could assist spatial planning at the local level, the representative from the national utility LKW described it best for formulating energy clusters that avoids conflicts between infrastructures (gas versus heating, etc.). Funds could then be appropriated according to the targeted measures by area. The model could also help redesign existing municipal structure plans in a way that better informs the public and private sector of the energetic potentials. One municipal official suggested it could be integrated into existing zoning plans and described in building codes, such as potential lines for future district heating networks or potential zones for higher performance building in the form of Minergie-P zones. According to another municipal planner, the model could also locate and size a number of small decentralised power plants across the municipality, optimised according to the needs of the location, that is, realising energy projects close to the final consumer, rather than accommodating a few large sites for energy projects without concern to the location of their eventual energy user. One national government planner emphasised the potential in designating areas for future certification according to energy performance, adjusting existing zoning regulations, and amending local energy laws (for example, making mandatory the connection to district heating). The primary function as a visualisation tool needs to remain simple asserted one national energy expert.

How could the Renewable Liechtenstein scenarios affect the National Structural Plan (Landesrichtplan), the municipal structural (Richtplan) or zoning plan (Zonenplan), the municipal energy structural plan (Energierichtplan) and the municipal building code (Gemeindebauordnung)?

Although energy scenarios can be progressively integrated into planning guidance according to one LKW official, there was no further explanation as to how this would be achieved. The only suggestion was to articulate energy clusters in order to mediate between energy supply structures. Public companies (such as the LGV, district heating networks, wastewater heat recovery systems) could focus specifically on the areas allocated to them in their infrastructure projects. Energy clusters could be identified in terms of the energy recovery opportunities and the avoidance of high-energy consumption transportation, differentiated according to the types of consumers (services, industry, residential, public) and the geographical area and altitude. The improved plan could also help inform cross-border projects in terms of public building and planning regulations required for optimising energy potentials. According to one municipal official, the National Structural Plan (Landesrichtplan) could be modified to differentiate the land ownership types, in order to identify available land for increasing development densification and to specify zones according to energy performance types. The Plan can moreover define the locations and areas for energy production. Another municipal official suggested created new zoning according to the available energy resources. The amended Plan must also consider existing national relevant measures such as the location of deep geothermal energy sources, asserted one national planning official.

With regards to the *municipal* structural or zoning plan, energy plan and building code, most officials agreed on the integration of the 100% scenario, but unlike the Structural Plan, there were no suggestions as to how this would be specifically achieved.

What changes would be needed to implement the following specific actions? Who bears responsibility for this?

Higher binding energy efficiency measures for new buildings and renovations

In Liechtenstein, the Swiss Minergie standard for new buildings is applied to the renovation of national public buildings. Applying the standard to the redevelopment of *all* old buildings is another possible measure according to one LKW official. However, a strong *legal framework* to implement this measure is essential asserted another utility official: “the national government must create the legal basis and at best assist with funding the rapid conversion.” One municipal official emphasised also the importance financial incentives. Furthermore, it would be imperative to increase information and communication with industrial and service companies where the greatest potential in reducing energy consumption resides in terms of heat, electricity and fuel for mobility according to another municipal official. While two municipal officials recommended even stricter legal requirements, one energy expert from Lenum preferred voluntary measures over forced measures, because it is not known whether builders in Liechtenstein will actually respond well to forced measures, compared to a more attractive support scheme.

Furthermore, it is unclear whether stricter rules are really necessary as existing building envelope rules according to the Minergie standard are already quite advanced compared to other European countries. According to one national energy expert, existing rules are already set at a high level. Therefore the focus should rather be on incentives to promote more ambitious targets: “the tightening of regulations can only help control measures implemented… to encourage innovation in such aspects as plus-Energy houses, monetary incentives instead of rules are best”. However, another national planning official sees further potential in amending the existing national Building Act to include tighter energy requirements. Such amendments argued one municipal official could occur in building laws at the national and local levels. In terms of responsibility, most designated the national government as the main player, while two municipal officials saw it also as a task for local government.

Binding energy smart power measurements for all building and connection to an intelligent network

Based on comments, this measure would primarily be the responsibility of the national energy provider, LKW, through smart metering devices and a countrywide intelligent grid system. Since the legal basis for smart meters is already a EU directive, the basis of implementation by the LKW is set. According to one LKW representative, the utility has already the ability to capture the data streams, and the additional energy consumption and measurement. This data is provided to all players centrally across the country (e.g. via the national energy office or on the Internet portal). However, by also accounting for the energy from the national gas provider and national water board in order to monitor the overall energy flows in the country, the network could be further improved according to two municipal officials.

Requirement for PV systems on the rooftops

Most experts (6 out of 9) were supportive of making the measure mandatory. However, based on the comments, this would require the sale of renewable electricity or trading, amendments to the existing building codes in terms of energy generation requirements, increased information and communication, monetary incentives, and political support. It would also require an understanding of the private economy and the big role it plays in influencing the adoption of the PV systems. But a singular focus on PV may not be sufficient. Two officials from the national electricity provider were sceptical of treating PV as an exclusive technology, preferring that they be treated within the context of the rest of the market, since PV systems according to one official “are an option, but not the only one.” In terms of responsibility, municipal officials often referred to this measure as both a national and local government task, compared to the national decision-makers who considered it primarily a national government responsibility, since they have the obvious capacity to revise the appropriate legislation in building, energy and market.

Design and installation of small decentralized CHP plants operated with biomass from sustainable forest management, waste, sewage or industrial waste heat

Most experts were supportive of such decentralised plants. One official from the LKW mentioned that only two systems types would necessarily be required out of the four (forest biomass and sewage biogas). The advantage of these plants was noted in their ability to compensate for the seasonal produce of energy due to the differences in the various renewable energy technologies. Like the PV systems, their implementation would also depend on market conditions according to several policymakers, alongside other factors necessary to optimise their implementation. Two municipal officials referred to the need for legislative support as well as communication to the wider population. The national energy expert emphasised financial incentives. The energy expert from Lenum focused on landowner contracts to determine and manage areas in connection with energy planning obligations. The national planning officer supported the integration of energy-relevant data, which showed the location of facilities, environmental assessments, and energy performance, into structure plans, land-use plans, and building codes. Half of the experts were likely to see this measure as a national government responsibility while the other half preferred it as both a local and national government task. The Lenum energy expert envisaged that actual implementation would ultimately be conducted by a contractor rather than by the individual governments themselves.

Design and installation of advanced district heating networks in industrial and commercial zones and residential areas with higher density

According to one LKW official, many of the larger loads in Liechtenstein are already supplied by cogeneration or combined heat and power (CHP) energy, hence it is questionable whether an additional, parallel network is needed. There are very few centers in which a district heating network would be cost-effective since the population sizes are small, and since some areas are already supported by the natural gas network. In view of the LKW's current financial budget development, it was argued that it would be difficult to implement such inefficient projects. Mandatory connections to deep geothermal plants however would be supported. This would however require legislation, subsidies and communication according to several municipal officials. Any new district heating network would also have to be part of a publicly accessible energy cadastre, while binding agreements with landowners for the construction of these networks would be necessary, argued the energy expert from Lenum. Zoning plans and building regulations would also need to undergo amendments to support this measure, argued the national planning officer. As for the energy source, waste heat should be prioritised over others, according to the national energy advisor. With regards to responsibility, five out of the nine officials referred to this measure as a national and local government responsibility, one national government official saw this mainly as a municipal task, while one LKW official emphasised the role of the private sector in its implementation. As legal requirements are necessary to definitively locate the heating networks, two officials referred only to national government intervention to provide the necessary legislation.

Construction of geothermal power plants

This measure was generally supported but several officials questioned as to how the plants would be financed. According to the national energy advisor, their construction is still too expensive. Although it was conceded that it remains a possible long-term option, especially since pilot plants were still essential, but this would only be achievable according to a few officials, in connection with the heating network provided by the Buchs waste incineration plant located across the border from Liechtenstein. Like previous measures, many municipal officials repeated the need for appropriate legislation, communication procedures, and attractive subsidies to implement geothermal power plants. Legal requirements in planning, and their documentation in local energy cadastres would also be important. Most of the officials agreed that the construction of a geothermal plant would primarily be a national government responsibility because of the need for supporting legislation, LKW involvement, and grants for further research. Only one municipal official saw the possibility of municipal involvement alongside the national government in this measure. However generally, it was agreed that the construction of geothermal plants by individual municipalities was too risky.

Wind power generation by large wind power technologies

There was overall positive support for this measure but further discussion and communication between the national government, municipalities and their communities is warranted according to most officials. Changes would be required in creating monetary incentives, and changes to the planning requirements at the national and local government levels with regards to the permitting processes. Five of the nine officials treated this as a national government task, one of which admitted that the cooperation of the communities would also be necessary (Lenum energy expert). Only two municipal officials mentioned the required participation of both levels of government. Interestingly, the two LKW officials referred to this as a purely community responsibility since it is up to them to decide "whether they want such drastic measures in nature and landscape for approximately 0.7% of the country's electricity consumption" – this is a particular reference to the Citizen's Cooperative in Balzers, which has been lobbying for the implementation of wind turbines in their locality.

Wind power generation by small and medium-sized wind turbines

Only two out of the nine experts were adamantly against the use of small and medium-sized wind turbines, since according to them (LKW officials), the income and expense in such facilities are "disproportionate" and that their analysis showed that "this technology in this country cannot be used effectively." However the remaining experts were generally supportive, even the national energy advisor and national planning officer, who repeated the need for legislative frameworks, subsidies and communications to support them. One municipal official reiterated the revision of planning codes to facilitate their implementation. While the Lenum energy expert asserted that support for such technologies was already present, citing the Liechtenstein Solar Cooperative (LS), which has actively led the promotion of wind power in the country. The expert noted that there exists great potential in extending cooperation between the LKW and the Solar Cooperative to implement more studies and projects in windpower and other RES. Two local government officials supported the involvement of both levels of government to implement this measure. In stark contrast, one LKW official insisted that it should not be a prerogative for any level of government.

Implementation of a medium-sized hydroelectric power plant with low environmental impact on the Rhine

All of the officials were supportive of this measure. One LKW representative regarded it as the first step to go in the direction of energy independence, however another official from the utility noted that its implementation must also consider the re-design of the riverine landscape in order to observe the flood and groundwater issues. Most municipal officials agreed that legislation and the sensitisation of the population would be critical, since according to the Lenum expert, "community resistance is inevitable." For the expert, "the potential is clearly greatest here [but] implementation would be the most difficult." Planning regulations would similarly need to be adjusted to accommodate this measure. Five of the nine officials who commented saw the measure as an LKW responsibility, while four noted that it is a national government responsibility given that the Rhine River is shared with Switzerland, and a treaty with Switzerland and the Canton of St. Gallen would be an obvious requirement.

The development of several small and medium hydropower plants elsewhere in the Principality

This measure was generally supported, but only as long as it was justifiable from the perspective of environmental protection and that sufficient energy potential exists to warrant its development. Like other measures, supportive legislation, subsidies and a communication strategy are essential. According to the energy expert from Lenum, hydropower at this scale is underestimated in the Principality since there is considerable potential for applying water turbines on drinking water networks for example. In terms of responsibility, a third of experts saw this measure as a task for LKW, a third viewed it as a national government responsibility and a third regarded it as a responsibility of all three parties: LKW, national and local government.

Following the questions on specific energetic measures, the decision-makers were then queried in relation to the institutional or governance methods, which would impact the implementation of those energetic measures. These methods are similar to those queried in the expert survey in Chapter 3.

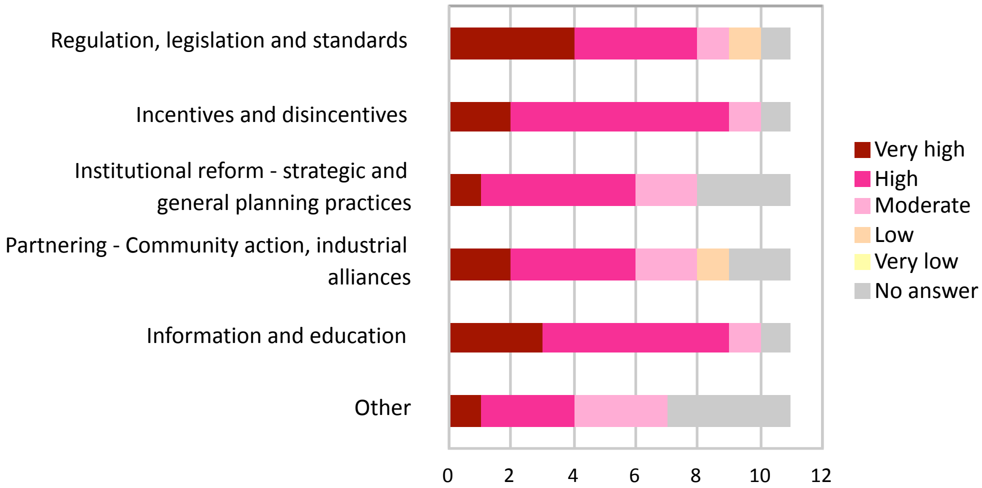


Fig. 119. Number of decision-makers responding to the question: "How do you assess the importance of these institutional methods to pursue energy autonomy?"

The workshop participants regarded regulation, legislation and standards most positively, while partnering was most likely to attract polarised views. Information and education, alongside incentives and disincentives tended to attract positive responses overall. Institutional reform with regards to strategic and general planning practices was the least supported method of all.

The following outlines the comments of policymakers with regards to each method:

Regulation, legislation and standards

According to one LKW representative, laws are acceptable only when they are shown to be sensible and reasonable, that they are financially manageable, and that the community is provided with the certain possibility to implement the measures. Another LKW official asserts that the legislative process is only the starting point, which must then "be steered with regulations and guidelines." However, any law such as the compulsory implementation of PVs is likely to be politically difficult to implement and could potentially incite opposition, argued the energy expert from Lenum.

Incentives and disincentives

Further incentives in purchasing energy efficient household appliances would be ideal to give consumers the impetus to switch more quickly but whether this should be supported by national subsidies is questionable, argued the LKW officials. However, any incentive that could influence the choice and decision-making of consumers is generally the right thing to do, asserted one municipal official. As for disincentives, these were rarely mentioned by officials, except for a brief reference to the carbon tax, which was considered "difficult" and "less welcoming". But "if the overall effect impacts 'the wallet', changes in behaviour can ensue", argued the energy expert from Lenum. For the spatial planner from the national government, a combination of both incentives and disincentives may in the end be necessary: "push and pull systems are recognized as the necessary requirements for implementation."

Institutional reform – strategy and general planning practices

Since municipalities have planned for and invested in their own energy planning, further reform should not be necessary according to one LKW official. Several experts were unsure as to what planning reforms actually meant, and what reforms could actually achieve.

Partnering – Community action, industrial alliances

Existing setups were argued to be sufficient according to most officials, however the increased involvement of the national Energy Office (Energiefachstelle) and LKW would be necessary and sufficient to achieve energy autonomy, rather than mandating the installation of a dedicated energy consultant in each municipality. Generally, the decision-makers considered partnering a positive move but this according to them, depends largely on the feedback of the community, and the involvement of pertinent parties to step forward and organise themselves voluntary. For one municipal official, partnering often provides “limited potential” because of the uncertainty in waiting for individuals, companies and other organizations to create alliances - which in itself does not provide a guarantee for implementation. According to the energy expert from Lenum, such measures can engender quick initial interest and motivation but “it is usually difficult to bring all parties under one roof [and] over a period of time.”

Information and education

The LKW officials highlighted that this makes sense since the energy transition must be understood by all but the only question was how the information should get to the consumer. The relevance and quality of information and the need to keep data up-to-date through on-going research is imperative, especially as technologies improve in performance and cost. The information, argued on municipal official, should even be tailored in order to influence the different types of lifestyles and consumption patterns. But although information and education is important, historically this has not meant an increase in the implementation of projects according to the energy expert from Lenum. Overall conviction in energy self-sufficiency still remains low in the Principality.

Other

Other methods suggested by the officials included an awareness campaign to promote the implementation of hydroelectricity on the Rhine or feedback systems for customers (LKW officials), steering duties or taxes and other simpler projects such as LED street lighting (municipal officials).

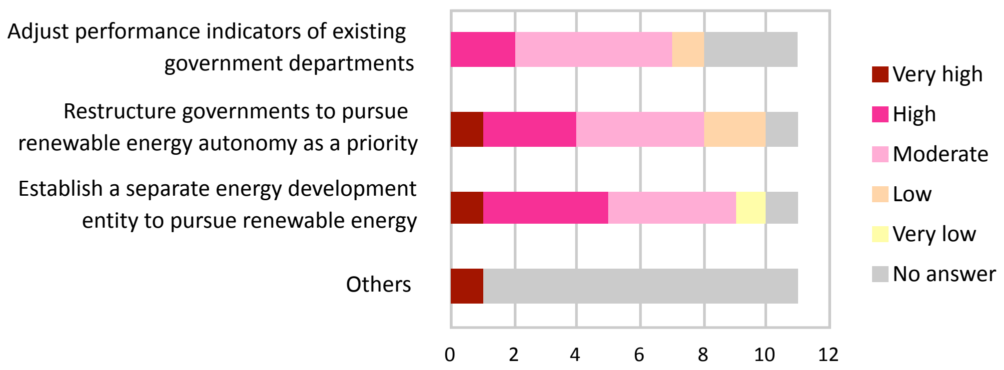


Fig. 120. Number of decision-makers responding to the question: “How do you assess the importance of these organisational measures in terms of energy autonomy?”

The decision-makers were most likely to have opposing views with regards to the establishment of a separate energy development entity to pursue renewable energy autonomy. There was however overall positive support for restructuring governments to pursue energy autonomy as a priority.

The following outlines the comments of policymakers with regards to each measure:

Adjust performance indicators of existing government departments

According to the LKW official, indicators have already been applied within workings of the Liechtenstein Power Company (LKW) and the Liechtenstein Gas Supply Company (LGV). They add that when applied to government departments however, indicators may have a limited sphere of influence. It is uncertain as to how government indicators would be also administered, argued the energy expert from Lenum.

Restructure governments to pursue renewable energy autonomy as a priority

The LKW officials opposed restructuring, since this according to them meant equipping agencies with even more power, and therefore increasing the likelihood of more regulation. The necessity for restructuring is also arguable given that current structures were not unfavourable. They noted that: "the public sector can set overall objectives within existing strategies they already own." However, restructuring could also mean the simple reorganisation and augmentation of existing resources with expertise in energy. For the Lenum energy expert, this means increasing staff resources at the national and local levels. However, others question the focus on restructuring as an issue. According to one national government planning officer, "it is not an organizational issue, but a ratings question."

Establishment of a separate energy development entity to pursue renewable energy autonomy

Due to the current financial situation of the Principality, creating new authorities or agencies would be problematic, commented one LKW official. Another official from the utility reminds that there is already a national Energy Commission, which advises the government in setting energy development goals. It is better therefore that the Commission is simply reinforced to pursue energy autonomy. Increased staff resources are warranted but it is unclear whether this would also mean the creation of a separate energy entity. For the national planning officer, entities responsible for energy already exist, whilst adding new forms would not necessarily guarantee implementation, instead they may backfire.

Others

One LKW official advised that any organisational measure would need to be cost-neutral in the process of restructuring and the use of existing resources. One municipal official preferred the establishment of a *coordination* unit at the country level to lead planning, energy and mobility alongside the municipalities that is strategically and operationally focused, instead of a *development* entity. One could argue this already exists in the form of the national Energy Office (Energiefachstelle), however it is reminded that the current Energy Office does not have executive influence on the regulation of buildings, spatial planning or mobility. Also, the Office has great control over the technologies – types, logistics, promotion, finance mechanisms – recommended to the municipalities, which may have impacted the preference of one technology over another.

Further arguments from the decision-makers workshop

A key recommendation of the Liechtenstein national government's Energy Strategy 2020 was to establish a network of co-operation not only with private households but also with local businesses and industry (Energy Commission, 2012), a measure also recommended by the Renewable Liechtenstein study. However, to involve local businesses and industries has been the least successful measure in Liechtenstein, according to the national government's energy expert. Reasons given for the failure: the emphasis on support programs for single-family or multi-family apartment houses by the local and national governments over incentive programs for entrepreneurs and proprietors to improve operational efficiencies and integrate renewable energy systems.

Although steering by law was admitted to be a more effective method to finally kick-start the measure, the legislation should be one, which provides a competitive basis for industry, according to officials. For example, mandating partnerships with the Solar Cooperative to provide an on-going operational network and preserving private investment, proposed by one municipal council official. Or in the area of sustainable transport, incentivising the collaboration with operators or car rental companies to offer electric charging stations, whereby the initial period would pave the way for the establishment of a market. Another remarked that some degree of legislation is necessary. One local planning official observed that the majority of the community comprised of people who would only act under duress (approx. 80%), compared to those who would act voluntarily (approx. 20%).

Liechtenstein's energy provider LKW considers it to be useful to discuss energy from a legislation point of view, in terms of pushing for a 3% renovation rate or an energy mix target, by optimising the current national energy efficiency law. On top of this, LKW admits that municipalities could always add more, which is already a common practice. The provider sees the further development of the energy efficiency policy as a very important concrete measure if the country wants to move in this direction. Although it admits that areas as roofs on public buildings and parking spaces present an enormous potential within the country, their use is ultimately determined by ownership factors. Hence, an improved energy policy, which tackles the issue of ownership would be imperative. It should also include provisions in municipal autonomy for local energy systems implementation, with the national government and LKW as support.

The majority of municipal officials preferred promoting support over regulation – that is, incentives and information over policies and legislation - particularly programs in cooperation with the national government. One important recommendation was education and awareness of climate and energy matters that went beyond Energy Days, free energy consultations, websites, energy consultants and annual municipal conferences. This aspect of learning has not been referred to in the Renewable Liechtenstein study, but was considered most helpful for local policy-makers.

Municipal officials expressed the need for further exchanges of experiences between communities in the region and awareness measures that target the decision-making bodies of the local and national governments, to enable councillors and official to make more informed decisions on energy policy, and to also understand the impact of planning decisions on energy consumption and generation. It was noted that at the local government level, consensus on energy policies have been very difficult to achieve because majority support was required from officials who only had a minor knowledge on energy. Some municipalities in Liechtenstein have admitted that the formulation and amendments of energy policies have solely been driven by a single individual. One municipal official who was responsible for energy describes his work as 'lonely' and that he has to 'fight' to address issues that most of councillors were reluctant to address, such as setting higher standards in building and construction. One local policy-maker noted that by presenting forecasts of future benefits during deliberations was the best method to overcome this struggle. Generally, a significant period of learning and readjustment has been necessary as municipalities become more integral in local energy planning. The education of elected councillors, not just those responsible for energy, will be essential.

With multiple inputs into the decision-making process, compromises have also prevented the implementation of a focused strategy, according to one local policy-maker. In many cases the municipal council has become overstrained with the information. For example: even if it decides "Yes to 2000-Watt-Gesellschaft" in a council meeting, it was most likely that in the next meeting this decision would be undermined by other issues. There is a gap of awareness and information about prior decisions. The speed of information is also felt to be too fast, particularly for the people who have not yet been sufficiently trained. There was a suggestion that awareness raising should moreover begin from primary school, however one could argue that this would a mean a waiting period of more than a decade before any impact can be felt. It is developing the awareness in existing decision-makers, which may be more critical.

A certain degree of communication is essential when cooperating and learning. The workshop revealed a consensus that measures between the local and national government have been uncoordinated, mismatched or overlapped. Competition amongst energy supporters and goal conflicts with other disciplines, have impacted implementation. Although the roles and areas of responsibilities of national and local governments have been clearly articulated in legislation and national energy concepts, most decision-makers expressed conflicting views with regards to specific energy systems and technologies since they differ in size, cost and capacity.

For many of the workshop participants, it made sense that the large-scale renewable energy installations such as deep geothermal energy, wind power and hydropower on the Rhine River would be better handled by the national government. However, little progress has been made by the national government to develop these ideas further as a cost-effective solution for the future. This is despite local support for their installation in the last few years, in particular for wind power. There are conflicting views as to who would be responsible for the small or medium scale installations such as the local combine heat and power plants, or electric charging stations for e-vehicles. Despite a push for building their local biogas plant by the municipality of Balzers, this initiative for example was stalled due to opposition from the national gas supplier, LGV. One municipal official argues that although municipalities are supportive of electric charging stations and would make locations available in the locality for them, they still did not consider it to be their task but the task of the national electricity provider, LKW, since they (the municipalities) do not think themselves as energy producers and therefore not in the service of selling energy.

There is a sense that the energy domain is strongly monopolised in Liechtenstein, traditionally so, by the national electricity and national gas supplier, and guided by the national government. Municipalities have been rendered fearful of treading on territories that they have not yet given the jurisdiction upon. Officials in the workshop noted that larger-scale renewable energy installations such as establishing local hydropower plant on the Rhine River, local wind power turbines between Triesen and Balzers, and local cogeneration plants would generally entail strong political opposition from the national level.

Most municipal officials felt that the latest national Energy Strategy did not really enable or reflect the true potential of local government involvement that went further than the Energy City program. They argued that communities are closer to the problem and that implementation is realized in the communities. They have a sense of awareness and willingness to implement, but this is an aspect, which has so far, according to them, been underestimated by the national government. If government is serious about its strategy, communities can become very strong partners. Furthermore, some local policy-makers argued that communities are progressing even further ahead than national government in terms of strategy and operations in energy. “Communities are actually already on their way, but the central government is still on the start attempt level.” There was a suggestion that the national government has even restricted local government, as several municipalities have become “lone fighters” according to some officials. There is a certain apathy to local government involvement, as reflected in one national government official’s inability to outline the measures that would assist municipalities to remain, as the official insisted: “active and be self-responsible”.

Several noted the limited number of initiatives carried out by the national government that directly targets local government action beyond the support for Energy City participation, and financing mechanisms for energy efficiency and renewable energy projects. The Energy City program for example has been administered by the municipalities with limited national government assistance. The local energy cadastres have been initiated, developed and funded entirely by the municipality themselves with little support or information from the national government. Feasibility studies for various local energy projects such as wind power measurements and potentials analyses for industrial waste heat recovery have also been self-financed.

Feedback from the workshop participants have indicated that the municipalities also require assistance in developing awareness raising and collaborative models with and for local businesses and industry. In order to directly motivate local businesses and industry in energy efficiency measures or investments in renewables, a measure which achieved little success between 2003 and 2013, the municipalities require assistance from the national level in analysing and promoting this energy and economic potential. The cost of the feasibility study for waste heat recovery from the Hilcona factory for example was completely borne by the local municipal government of Eschen. The national government in this case could have assisted in supporting this study in monetary and legal terms. Indeed, it is the day-to-day dealings of local government with local businesses and industry, which municipalities moreover require assistance. Another example is the contracting of local companies by local government to conduct energy audits of businesses and industry, with referrals to other local building companies to carry out the actual renovating work.

Besides engaging industries, a lot of work needs to be done to convince all other stakeholders, and this too requires national government assistance. Support is required in developing the knowledge of local councillors in energy through a possible scheme organised by the national government. Another method of driving conviction would be the implementation of flagship initiatives. A flagship project could not only boost local pride and economy but also motivate other municipalities to follow suit. While incentives are useful, real projects could provide an observable demonstration of visions made more tangible. The national Energy Office could extend its service in subsidy allocation to providing free consultation to businesses and industry. At present, municipalities are providing this service but only for small building developments. A coordination center of ideas and projects at the national level, such as an energy taskforce, could help avoid party-related fragmentation of interests, asserted some of the officials.

One deficiency of the current national Energy Strategy 2020 was noted to be the exclusion of the municipalities in the formulation of the recommended measures. This is reflected in the minimal presence of municipal responsibility in its list of 43 measures. The only local government reference was with regards to the Energy City program; the Slow and Active transport program; optimising energy efficiency within the public water and wastewater treatment system; and contributing to energy cadastres for building and parking. Most officials agreed that when devising a national energy strategy, municipalities should have been included in its development, and not be considered separately, even if they possess widely different capacities and can only make specific active contributions. Although the Energy City label has been a lot of effort for most municipalities, and to involve them in further projects would go beyond their capacities, policymakers still considered their presence in the decision-making process essential to maintain overall political and ideological support for national goals.

5.4.3 Factor 3: Local government discretion

The municipalities of Liechtenstein have their historical roots in the village cooperatives with their predominantly rural-economic tasks, and in the community courts, which had mainly political tasks. In 1809, when the Courts of Communities were dissolved, their functions were transferred to the eleven municipalities that were granted the right of self-government within the municipality laws of 1842 and 1864. Today, Article 4 and 110 of the national constitution (LR101) defines the rights of the individual municipalities based on the concept of *municipal autonomy* (Gemeindeautonomie). Article 4 states that the communities have the right to organise and manage their own sphere of affairs under the supervision of the State [national government], while Article 110 outlines the rights to certain responsibilities:

> 'a) free election of the mayor and other organs of the municipality by the municipal assembly; b) autonomous management of the municipal assets and the administration of the municipal police under the supervision of the national Government; c) maintenance of well-ordered services for the poor under the supervision of the national Government; d) the right of the municipality to grant citizenship and the freedom of Liechtenstein citizens to reside in any municipality.'
>
> (Translated from LR101, No.15, 1921, pp. 41-42)

The national Local Government Act (Gemeindegesetz [GemG], 1996) defines more definitive tasks for local government, its councillors and mayors, adapted at the local level in the form of the statutory Local Government Ordinance (Gemeindeordnung). Although there exists individual municipal Acts, such as the Gemeindeordnung Vaduz, the Gemeindeordnung Gamprin etc, they are essentially the same in content. The tasks of the municipality, as per Article 12 includes:

a) the election of municipal bodies
b) the organization of community
c) the award of civil rights
d) the management of community assets
e) the construction of public buildings and facilities such as schools
f) the collection of tax assessment
g) the promotion of social, cultural and religious life
h) the establishment and maintenance of nursery and primary schools
i) the maintenance of peace, security and order
j) the local planning
k) the water supply and sewage and waste disposal

(Translated from GemG, 1996, No.76, pp. 4-5)

Historically, the autonomy of the municipalities has been demonstrated in the introduction of women's suffrage at the municipal level. When the constitutional amendment of 1976 gave the municipalities the choice to grant voting rights to women, Vaduz was the first municipality to enact this right, with the rest of the municipalities adopting the policy over the following 10 years.

The capacity for local government to carry out their own actions and manage municipal assets independently is principally driven by municipal revenue from local taxes and subsidies. The municipal council is elected by the citizens of the municipality, the assembly of which is headed by a Mayor, who would perform his duties either full or part-time depending on the size of the municipality. The decisions of council can be overturned through a citizen's referendum.

In addition to the Articles of the Constitution defining municipal autonomy (LR101), federal spatial planning and building laws stipulate that councils should manage local urban development, but in deference to the National Structure Plan (Landesrichtplan), the national Building Act (BauG, 2008) and the four national energy laws (EEG, 2008; Energy Efficiency Ordinance [EEV], 2008; Energy Efficiency Certification of Buildings Act [EnAG], 2007; Energy Ordinance [EnV], 2007). With sovereignty over local planning as stipulated by the Zoning Law of 1947 and the Local Government Act of 1996, they have the right to employ instruments such as pilot projects, structure plans, zoning plans and target-oriented implementation measures. Municipalities are free in defining goals for spatial development of their territory, guided by the conditions set by the national Spatial Structure Plan (Landesrichtplan). Although the Spatial Structure Plan is in itself a non-binding, purely advisory document, it creates a spatial framework for municipalities to freely fulfill their own sphere of activity, but within the confines of the national spatial planning guidelines that function to harmonise activities. Each municipality has the right to amend local codes such as revisions in the local zoning (Zonenplan) and building regulations (Bauordnung).

Table 13. Energy and planning instruments at the municipal and national levels.

Level	Spatial planning tools	Energy tools
Local	Zoning plan (Zonenplan), Building regulation (Bauordnung).	Energy efficiency and Renewable Energy Support Program (Energieeffizienz und erneuerbare Energie-Gemeindeförderung), Waste code (Abfallreglement), Water supply code (Wasserversorgung Reglement), Sewage code (Abwasserreglement).
National	National spatial planning plan (Landesrichtplan), Building Act (BauG, 2008).	Energy Ordinance (Energieverordnung – EnV, 2007), Energy Efficiency Certification (Energieausweisgesetz – EnAG, 2007), Energy Efficiency Act (Energieeffizienzgesetz - EEG, 2008), Energy Efficiency Ordinance (Energieeffizienzverordnung - EEV, 2008).

Overall, there is very little difference between the spatial planning and building approaches between municipalities. In organisational terms, both local planning and building is generally the responsibility of the building department in each local government. Only Triesen has a dedicated department for spatial planning. Energy is also the responsibility the building department, but sometimes addressed separately through separate municipal offices dedicated to infrastructure, public building, real estate or Energy City.

Each municipality in Liechtenstein (except for Triesenberg) has in force a municipal zoning plan, which works in tandem with the municipal building regulations. Like the municipal building code, the zoning plan is binding (statutory) and determines the limits to urban development. Municipal zoning plans function primarily as maps that delineate between existing and potential land-uses and designated building densities. Each zone is further explained in the building code (Gemeindebauordnung) with regards to allowable heights, densities, length and built form. Except for the zoning plan of Balzers, which provides a dedicated zone for energy production (but only to denote the small plot of land where an existing biogas facility currently sits), none of the other municipalities have allocated potential zones for energy generation or for the implementation of future networks such as a district heating network in their zoning plans. In the case of Balzers, despite the minor site allocation for a biogas plant, the rule governing this new zone was progressive in terms of the provisions guiding it, whereby the permission of installation of energy supply structures and equipment in the dedicated zone could only be granted if the operator can guarantee the restoration of the site once the biogas buildings and grounds became inoperable.

Liechtenstein municipalities have in recent years relied on an Energy Structure Plan (Energierichtplan), a non-binding document that illustrates the energetic aspects of their local government area and which functions separately to the local zoning plan. Six of the municipalities have already commissioned their own with two being planned. The Energy Structure Plan is essentially a hybrid inventory-potentials map that sets out a record of all the renewable energy installations implemented in the community, and the areas with the potential for renewable energy recovery for electricity and heating. This inventory includes the technologies such as PV panels and solar thermal systems on roofs and facades, renovated buildings, biogas plants, wood chip or pellet heating systems, and sewage or waste heat networks; and includes the energy potentials such as groundwater and geothermal energy recovery, hydropower, and wind energy. Unlike the zoning plans and building regulations, which are publicly accessible via the Internet, the Energy Structure Plans are proprietary documents and are kept for the local government eyes only, with its direct use requiring special permission from the municipal council. Another proprietary map is the Energy Cadastre Plan, which is another non-binding map commissioned by almost all of the municipalities (2 of 11 are in the planning stages). The Plan is also an inventory map, which colour-codes areas in the municipality according to their heating and energy consumption. The Structure Plans and the Cadastre Plans of the municipalities were all created by local energy advisory company Lenum AG.

The statutory municipal building code (Gemeindebauordnung) governs basic building development with regards to the heights, lengths, floor space ratio, open space ratio, boundary conditions, roof types, roof angles, façade orientation, and size of openings, all depending on the zone type as delineated in the zoning plan. Historical village centre zones, usually characterised as core zones have the most stringent requirements, in particular rules governing roof types, roof angles, building construction, colour and material. The individual zoning regulations do not substantially differ between municipalities. With regards to renewable energy installations, only 6 out of 11 municipalities have specified rules, but mostly with regards to the placement of solar PVs and solar thermal collectors. Like the national spatial regulations, mandating high performance in new and renovated buildings or recommending a particular energy efficient building or urban development type such as compact housing have not been stipulated in any of the codes.

There is great potential to employ the statutory local zoning and building regulations to influence energy use and production by local government. However, a review of the regulations from each of the municipalities reveal that local guidance for optimising energy efficiency or for promoting renewable energy installations have been absent, restrictive or rudimentary. As for renewable energy installations, even those that provide distinct sections within their municipal code with regards to PVs and solar thermal (either as an additional Article, Appendix or as extension to existing Articles), include instructions that are generic and sometimes vague. For example, PV installations may be allowed but they can only be installed as long as they do not disturb the overall townscape and landscape character. Although guidelines on panel sizes, arrangements and fixings are often described, there are no supporting illustrations that showed acceptable forms of integration that avoids such ‘disturbances’.

The review indicates that the installation of PV and solar thermal panels is generally allowed by 6 of the 11 municipalities. Conditions dictate their positioning - primarily on roofs, but not on facades (except for Ruggell, Planken and Balzers), outdoor structures or on the ground. The panels should be well integrated with the roof, follow its slope, installed flush as much as possible, remain within the roof area, and harmonise with the roof’s colour. They must also be in keeping with the heritage of the locality and in particular, the roof forms of the specified conservation areas. Some municipalities define more exacting rules with regards to positioning and arrangement. In Triesenberg for example, the abovementioned rules apply but panels should also keep a distance from the roof edges of a minimum of 4 times their height (of panels), and be arranged in a continuous and rectangular manner, rather than in a U or L form. If more fields are necessary, symmetry, regular repetition and parallel lines must be maintained. Generally, rules are restrictive in all local building codes: panels must not go beyond the roof edge, must not be of a thickness with fixings that dramatically extend from the surface of the roof, must not cause reflections or glare to neighbouring properties as well as the users of the public space, and they must not interrupt the local townscape or landscape. Systems in the landscape are prohibited, such as solar thermal and PVs panels that are ground-mounded or fixed on-to fences, walls or other similar low-lying structures. Although the amount of solar installation is naturally restricted by the available roof size, in Triesenberg, a maximum $6m^2$ per unit of solar collectors for heating or hot water production or PVs is only permitted.

PV and solar thermal panels are usually prohibited in village cores, particularly PV installations. However in Ruggell, solar thermal systems is permitted in historical sites if it can be shown that they are imperceptible and do not adversely impact the visual quality of the area. Ruggell, Planken and Balzers are the only municipalities to allow for the integration of solar systems on facades, but only subject to local authority approval.

As for other renewable energy systems, the installation of small wind turbines is referred to by Ruggell, Triesen and Balzers, but only as a warning that the systems are not allowed in most of the already zoned areas. Large turbines are acceptable in designated areas but still subject to municipal assessment. In the rest of the country, systems such as heat pumps, small hydro and biomass installations are not referred to in any of the eleven building codes. Only six municipalities state exceptions to the abovementioned restrictions, but this depends on their own municipal assessment of individual projects.

Table 14 lists the individual municipal renewable energy installation codes:

Table 14. Municipal rules governing renewable energy system installation (Source in italics in table).

Municipality	Code
Vaduz	None
Triesen	Article 3: Installations are allowable, but if they interfere with or impair the local landscape or endanger road safety, they must be assessed in each individual case. No attachments are allowed on garden fences or surrounding walls and the like. Article 4: Solar thermal panels need to be integrated into the roof area, except for special cases, e.g. slate roofing. The collectors must have the same slope as the roof slope, excluding flat roofs. Detached systems in the field/landscape are not allowed. Article 5: PV systems are not allowed in the village core area. PV systems need to be integrated in the roof of new buildings. The PV modules must have the same roof pitch as the underlying sloping roof. Detached systems in the field/landscape are not allowed. Article 6: Small wind turbine systems (up to 5 kW) are not allowed in residential zones A, B, C, core zone, K, DK, village center zone and Service Zone D. Small and large wind turbines (5 kW) are both subject to a special approval process. Article 7: A concept for alternative power generation facilities for a new development that has emerged from a redevelopment plan is allowed. Article 8: Solar panels, PV panels and wind turbines located at critical locations, and building integrated solar thermal and PV systems are to be submitted in the preliminary application to the planning authorities for evaluation. Article 9: In consideration of public and private interests, as well as evaluating the particular circumstances of each case, the council may allow exceptions to these regulations. *(Translated from Triesen Building Regulations, Appendix 6 - Rules for Alternative Energy Generation Systems, 10.02.2009)*
Balzers	Article 20 - Zone for energy supply (EV): In this zone energy supply structures and equipment are allowed, but when the buildings and grounds are inoperable, the operator is obliged to cancel the buildings and grounds and to restore the site. (*Translated from Balzers Building Regulations*) Article 3 – Principle 1.Systems affecting the local and cultural landscape, including natural monuments and traffic safety must be assessed in each individual case. 2. No attachments are allowed in the garden, on surrounding walls, fences and the like that goes over public space. 3. Systems (solar panels and PV) in the terrain must be assessed in each individual case. 4. Systems (solar panels and PV) in conservation zones are not allowed. Article 4 – Solar thermal and PV systems 1. Solar panels and / or PV systems must be integrated into the roof surface. Only in special cases (substructure of the roof surface, such as sandwich structures, sheds), or if the roof flush installation would mean a disproportionate effort, are exceptions possible. The overall roof surface must not exceed 20 cm. 2. In core zone K, village core zone DK, village zone D and with new buildings in all zones only roof-flush, integrated systems are allowed. Surfaces that can be seen from the public domain are to be judged in individual cases. 3. The collectors have to have the same surface inclination as the inclined roof underneath. The horizontal lines and side borders/edges as special visual characteristics of building are to be paid attention to. For a good integration of a solar collector or PV system into an existing structure, it is important to respect the contours of a building. The modules must not extend beyond the building contours/outlines/profile/shape). Connection lines are to be integrated into the new construction. Existing building and renovation conduits on facades are to be

Municipality	Code
	carried inside a tube or a clean cover (analogous to rain water drains). 4. For flat roofs, structures on stilts are allowed, but design measures are to be taken (eg high roof edge, positioning the system in the centre of the flat roof etc. the different fields should not be mounted higher than 140 cm and in a suitable distance from the roof edge (distance = at least height of the fields). Field heights higher than 140 cm are only possible when argued sufficiently and in writing. Article 5 - Facades 1. In the village center zone and village zone, energy recovery plants on facades are not allowed. 2. In other residential zones, systems are to be installed flush with the edge of the facade. The collectors should be integrated into the façade, for example to components such as window sills, balcony railings, etc., and are fully covers the surface. 3. The plants are preferably affixed to surfaces, which face away from the public space. Article 6 - Windpower 1. Small systems (up to 5 kW) are not allowed in the residential zones A, B, in the core zone K, Village core zone DK, village zone D and the residential zone WA. From the standpoint of local structural conditions and protection of the landscape, small wind turbines are possible in the other zones. All requests must be submitted to the building authorities for evaluation. 2. Large plants (5 kW) are subject to a special approval process. 3. Wind turbines in the landscape protection zone and the LS Conservation zones are not permissible. Article 7 – Development control plan 1. In a development for alternative power generation facilities, a redevelopment plan that shows the concept should be established for the entire redevelopment plan perimeter, showing the product, the arrangement, colour etc. The concept is to be submitted to the authorities for assessment before a building permit is issued. (*Translated from Rules of the Municipality of Balzers for Energy Recovery Systems*)
Triesenberg	Article 22: Solar energy systems for active and passive use of solar energy are permitted if they do not interfere with the townscape and are integrated and architecturally designed in existing buildings and facilities. *(Translated from Triesenberg Building Regulations, 14.3.2006)* Article 16(7): Solar panels are permitted on the roofs, when it does not significantly affect landscape, and respects the following requirements: a) Solar panels should complement the roofing material in terms of colour and texture, should be mounted flush with and with the same inclination as the roof, integrated with the roof surface. For existing buildings, exceptions to colour matching and flush mounting are possible. b) Solar panels are especially arranged so that they are relatively inconspicuous. c) The solar collectors for surface heating or hot water production or PVs are restricted to max. 6 m^2 per unit. Total roof area is permitted if good integration into the townscape and landscape is guaranteed. *(Translated from Steg Building Regulations, 5.6.2007)* No rules specified for renewable energy installations in Malbun. *(Malbun Building Regulations)*
Schaan	None
Planken	Article 30: 1) Solar energy systems are permitted if they do not interfere with the townscape, and should be well integrated and architecturally designed. 2) Solar energy systems must be installed on roofs in the same slope as the roof and shall not exceed the boundary of the roof surface. In new buildings or renewals, systems should be

Municipality	Code
	flush with the roof. If this is not possible, panels and fasteners should be chosen with a low overall height. Solar energy systems are to be arranged and designed that they as an architectural element contribute to a good overall efficiency of the building and its surroundings (full-scale collection panels, respecting distances to the roof edges, obtaining the unity of the roof surfaces, observing the contours of the roof landscape, and so forth). The colour of the panels and their attachments should complement the roof or façade. Solar and PV systems must not cause reflections or glare to neighbouring properties as well as the users of the public space. *(Translated from Planken Building Regulations, 03.04.2012)*
Eschen-Nendeln	None
Mauren-Schaanwald	None
Gamprin-Bendern	Article 24.3: Solar panels for alternative heat recovery and power generation is permitted if there is good integration into the roof area in question and that the surrounding roofscape is ensured (colour coordination of the roofing material with solar panels, roof assembly within the area in terms of location and angle). Glare from panels is to be avoided. *(Translated from Gamprin Building Regulations, 03.02.09)*
Ruggell	Article 3.1 Solar energy equipment a) The installation of solar and PV systems is notifiable (Art. 73 BauG, 2008). Solar systems for hot water and heating are used for supply of the building on which the solar panels are installed and are therefore tied to the locality. PV systems feed the electricity generated in the general supply network and therefore are not location-bound. b) Solar and PV systems on roofs and facades can damage historic sites, hence public and private interests must be considered. Public interests are given more weight. In the protection and conservation areas as well as in the field of natural and historic monuments, solar and PV systems are only permitted if they are imperceptible. Mainly in built-up areas, it is important to preserve the existing neighbourhood character, with solar panels must fit into the overall picture. c) On steep roofs, solar panels should be installed in the same slope as the roof surface. In new buildings or for a renewal of that roof a flush installation is required. 'Dachbündigkeit' means that the panels go only slightly beyond the building height and roof surface. If a flush roof is not possible, panels and fasteners should be selected with a low overall height. Freestanding or mounted solar panels on retaining walls are not allowed. On facades, solar panels are only permitted if good design as well as functional integration can be demonstrated. Panels on flat roofs are possible as long as it is imperceptible from the ground level. The appropriate material and colour of PV and solar panels mounted on the same roof should ensure a unified whole. Solar and PV systems must not cause reflections or glare over neighbouring properties or the users of public space. Article 3.2 Roof assemblies, transmission and reception systems and small wind turbines c) Wind turbines are not allowed in the residential zones, the core zone, and mixed zone. In the industrial and commercial zone, zone for public buildings and facilities and the agricultural zone, small wind turbines (up to 5 kW) permitted if this results in no degradation to the local and landscape. All applications must be submitted to the council for evaluation. *(Translated from Ruggell Building Regulations No.32, 11.09.2012)*
Schellenberg	None

5.4.4 Factor 4: Local energy potentials models

As shown in the previous section 5.4.3, legal and planning tools exist that could drive implementation. However the development of the local energy structure plans and energy cadastres has required careful local energy evaluations by local government, with the scientific work itself being usually undertaken by external energy experts. A review of local energy potentials models by the eleven municipalities reveal that nearly all of the municipalities have engaged in such analyses, but only one has developed a long-term development strategy based on the findings.

The municipality of Triesen was the only local authority to commission its own area-wide *renewable energy potentials* study, which culminated in a series of three reports: Energy Concept for Phases 1 and 2, in the years 2008 and 2009 respectively, and an Energy Cadastre combined with an Energy and Climate Protection Concept in 2012. As for the remaining local governments, five out of the eleven have their own Energy Structure Plans (with two in the planning), which define areas for potential energy recovery from geothermal, groundwater and waste heat resources. (It is important to note that the geothermal and groundwater resources are based on the national online energy database, which maps these energy potentials right across the country.) All energy structure and cadastre plans have been formulated by energy advisory company Lenum AG, based in Liechtenstein. As stated earlier, these plans have been treated as confidential documents, and are only for the use of the municipality administration. As a consequence, access to the plans has been very difficult. Access to the energy potentials study for Triesen for instance was denied by the mayor, possibly to avoid competition with neighbouring municipalities, or due to the incompleteness of the reports. However, as a public body elected by the local tax-paying community, one questions whether administration activity should be more transparent to its electors. Indeed, if the studies are to be implemented, the wholehearted participation of the entire community is essential, which means access to such information will be warranted.

Another critical intervention in the development of local energy potentials models has been the activities of the Liechtenstein Solar Cooperative (LS), which has organised several studies for local windpower (n=9) for the municipalities of Balzers, Triesen, Ruggell and Schellenberg. Unlike the energy concepts and energy structure plans of individual municipalities, these studies are publicly accessible and readily downloadable.

Table 15. Local wind energy potentials studies in Liechtenstein.

Windfield analysis	**Client**	**Contractor**	**Year**
Balzers	Liechtenstein Solar Cooperative	Weatherpark GmbH	2008
Balzers-Neugüeter	Liechtenstein Solar Cooperative	Weatherpark GmbH	2008
Triesen Hälos	Liechtenstein Solar Cooperative	Weatherpark GmbH	2009
Balzers Alp Lida	AXPO (formerly Northeast Switzerland Power Company, Nordostschweiz Kraftwerk AG, NOK)	AXPO	2010
Balzers Ans	Liechtenstein Power Company (LKW)	Sunergy GmbH	2010
Balzers Fläscher Riet	LKW	Sunergy GmbH	2011
Ruggell/Schellenberg	Municipalities of Ruggell and Schellenberg, FL national government	Sunergy GmbH	2012
Fläscherberg	Rii-Seez Power, Förderverein IES (FV-IES), Balzers Community Cooperative, Liechtenstein Solar Cooperative, Commission for Technology and Innovation (KTI)	Interstaatliche Hochschule für Technik NTB Buchs	2012
LKW	LKW	Sunergy GmbH	2012

5.4.5 Factor 5: Local government organisational change and augmentation

In each municipality, energy-related matters are usually subsumed within the departments of building (Hochbau) and infrastructure (Tiefbau). Personnel in-charge of energy-related matters are officials who are normally responsible for building, construction and engineering works. They would handle queries concerning subsidies, planning procedures, and general advice on energy efficiency and renewable energy. The municipal energy commission would always consist of these persons alongside other representatives, though not always, who are responsible for the environment, economy or community (Bürgergenossenschaft). The commissions are usually led by specially elected members. Only in the municipalities of Vaduz and Mauren does the mayor also chair the commission. Each energy commission always includes one external energy advisor, usually contracted by the municipality to provide a range of specialised energy services, including local energy accounting, translation of energy figures into energy cadastres, advice on local measures, preparation of Energy City reports, and development and implementation of sustainable strategies for the municipality. Local private energy advisory company Lenum AG has been employed by most of the municipalities to carry out this advisory task, and has therefore become integral to local government augmentation in Liechtenstein.

Essentially, Liechtenstein municipalities have relied on existing staff, a remobilisation of individuals into an energy group within the existing local government structure, with an addition of an independent, external energy advisor to pursue the Energy City accreditation. The municipalities also liaise directly with the national government's Energy Office (Energiefachstelle) to be kept informed of the latest amendments in energy policy. In particular attention is made of changes to the national feed-in tariffs and national subsidies, which inevitably influence the scale of local subsidies that are also currently provided by the municipalities through their own funds.

Unlike the case studies in the previous chapter, there are no entities through which municipalities can wield influence on local energy services or research, except through the Liechtenstein Solar Cooperative (LS), in which all of the municipalities, alongside the national government and private entities, provide shareholder contributions. The Solar Cooperative serves as another important augementation to local government organization to deal with renewable energy implementation.

Liechtenstein Solar Cooperative

The Liechtenstein Solar Cooperative (LS) is a local non-profit organization that works to promote the use of solar energy, and more recently other RES in Liechtenstein, and is involved in the running of a range of projects from large-scale PV installations on government buildings and bridges, to wind measurements analysis, consumer surveys and public events. In May 2013, the Solar Cooperative's capital was CHF 1,071,000, of which 12% consisted of private funds, 25% national government and 63% municipalities. The solar panels on the Rhine bridges in Bendern and Vaduz for example were realized on the basis of generous donations to the Cooperative from all over the region. The Cooperative has worked with many local governments to implement solar PV projects on municipal buildings, made possible through special financing arrangements with the national energy utility LKW. Since 2008, several wind measurements have been conducted in Balzers and Triesen on behalf of the Cooperative via the company Sunergy GmbH in Buchs SG, with the support of the Balzers Community Cooperative, regional energy company Rii-Seez power, the Friends of the Institute for Energy Systems at NTB (FV-IES), and the Institute for Energy Systems at the Interstate University of Applied Sciences of Technology in Buchs, Switzerland (NTB). Since March 2012, the Cooperative has also engaged in research on the wind conditions in Ruggeller Riet, a study financed with the municipalities of Ruggell and Schellenberg, and the national government of Liechtenstein.

Established in 1992, the Solar Cooperative was originally founded in reaction to proposals to build a nuclear-power plant and a coal-fired facility near the municipality of Ruggell, Liechtenstein (Franke, 2012). Its founders realised that through the Cooperative, they could explain and demonstrate an alternative energy supply system to nuclear and fossil fuels. It would provide a favourable platform to create this awareness, and encourage active implementation based on the principal strategy of combining the available theoretical and practical knowledge with political knowledge to promote solar energy utilization. The first success for the Cooperative was the drafting and uptake of the national energy efficiency law, which was based on the Cooperative's original promotion model for the direct use of solar energy. The promotion model aimed not to build at the first instance but to influence private owners to invest in solar since most of the roofs in the country were privately owned.

In its 20 years of operation, implementation has not been easy for the Solar Cooperative. There were several failed attempts for PV systems on public buildings such as the Liechtenstein National Art Museum, the historical wooden bridge over the Rhine, the Upper School, the Spoerry Factory Building (now housing the University of Liechtenstein) and the National Parliament building, all in Vaduz. The National Art Museum for example could not allow a PV system, because it masked the natural light from the roof openings required to illuminate the paintings below. And being the only wooden bridge across the Rhine River, the local council of Vaduz followed the recommendations of the historical protection group to reject any installations on it. The PV system on the Upper School was rejected for reasons of cost, even though the Cooperative did not consider the numbers truly justified. As for the solar system on the Spoerry Factory Building, a proposal was similarly rejected by the national building department due again to the possibility of initial high costs, even though it was demonstrated that construction would have been very easy and cost-efficient. For architectural reasons, a PV system on the National Parliament building was also rejected. In the municipality of Triesen, rejection to a PV system was based on the inability for the local Music School to carry the loads, the reasons of which the Cooperative was sceptical of but was unable to do anything more. Another setback was the introduction of a ban on PV systems in the village zone of Triesen and the rejection of additional national government financial support for the proposed wind energy potentials study in Liechtenstein's Highlands (Oberland). In the case of the latter, reasons behind reducing the capital contributions were related to perceived low opportunities in domestic wind energy, noise and landscape protection concerns, and the tense situation in the state budget (due to the then financial crisis of 2009). According to the former president of the Cooperative Helmuth Marxer, the national government generally did not have courage to push wind energy. They accepted the criticisms provided by the landscape conservationists without allowing further debate. According to Marxer, there was actually no intention to allow debate in the first place. In fact when they attended Parliament he noted that the Cooperative was not taken seriously, and were even "laughed at."

The lack of a debating platform for RES proposals was also reflected in the rejection of the Cooperative's support for new hydropower installations on the Rhine, which was undermined by issues of local ecological impacts, insisted by the Liechtenstein Association for Environmental Protection (Liechtensteinische Gesellschaft für Umweltschutz - LGU). Despite the lack of opportunity for further discussion on dams on the Rhine, the Solar Cooperative has since pursued other projects to harness water energy on the river, for example, a project for floating buoys to generate electricity, with suitable manufacturers already contacted to examine its feasibility for future implementation.

Indeed, the ability of the Cooperative to implement and not just to promote was further reduced in the recent rejection by the national government to a proposal for creating a performance agreement between the country and the Solar Cooperative. Based on an evaluation by an external company, the then Deputy Minister of Economy, Martin Meyer, had decided that the Cooperative would best operate only as an active, independent non-governmental organization that maintains existing promotions and collaborations. The Cooperative was admittedly important but primarily as an intellectual and reliable partner for publicity. This attitude was also reflective in the comments of Ernst Hanselmann (President of Regional Planning 1992 - 2007), who remarked that the work of the Cooperative, taking the example of the solar installation on the Bendern-Haag bridge over the River Rhine, really concerns the development of " a common [regional] image and identity."

Despite these difficulties, the work of the Solar Cooperative has played a huge role in influencing policies and action by the national government and the national utility LKW. In 2013, there were new plans by the national institutions to conduct a nation-wide wind power potentials analysis, and to produce a nation-wide solar cadastre.

With the financial backing of the municipalities and through the support of their communities, the Solar Cooperative can more easily implement projects that individual local governments may be reluctant to finance. This may be due to financial limitations (minimal subsidies from the national government) and social impediments (in avoiding competition with other local authorities in order to maintain the status quo), since all of the stakeholders in Liechtenstein are investing in the one entity, and each possessing a real economic stake in all of the projects implemented. This is particularly important in a tiny country such as Liechtenstein. At the local government level, there is a real opportunity for municipalities as the largest stakeholders in the cooperative (63%), to provide greater feedback and influence in projects, a capacity not otherwise available to them. The real challenge facing the Solar Cooperative is to inspire, motivate and mobilise relevant parties to implement future projects.

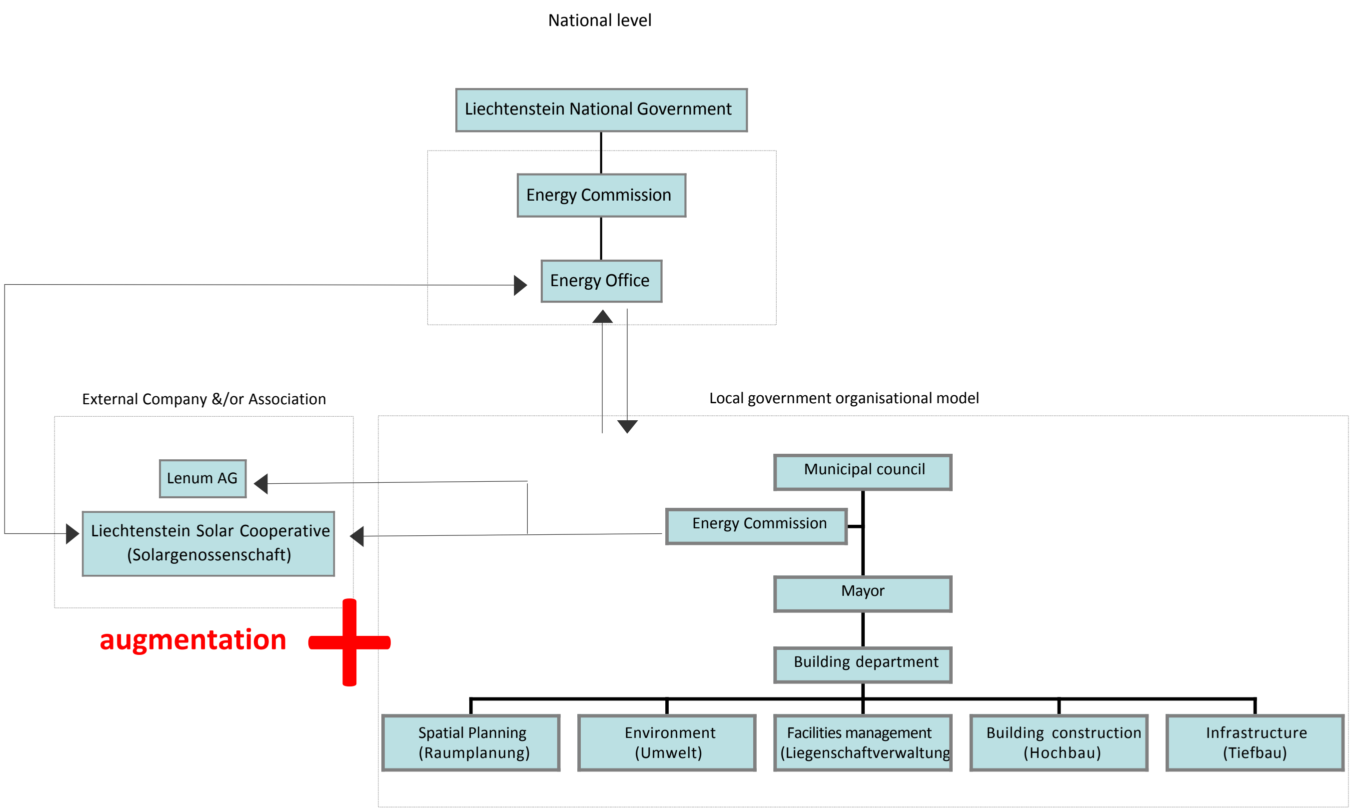


Fig. 121. Typical organizational model governing energy policies and programs in Liechtenstein.

5.4.6 Factor 6: The role of the national government

The national government of Liechtenstein provides the legislative framework for promoting energy efficiency and the use of renewable energy in the Principality. However this is primarily targeted through the regulation of individual buildings. On the basis of European climate objectives, which have been adapted as national goals, the country has enacted a series of energy and building laws that local government must adhere to. Municipalities are free to set their own goals and targets as per the law on municipal autonomy, but they must still maintain compliance with national energy and building policies. Although local planning through zoning and building codes is binding, spatial planning does not have a statutory role at the national level in Liechtenstein. However, the potential exists for local governments to adapt their own planning rules to achieve more ambitious energy targets. At the national level, there is also an opportunity to integrate energy as a planning requirement through the National Structural Spatial Plan (Landesrichtplan) or via a new National Energy Structural Plan (Landesenergierichtplan).

National climate objectives and their limitations

For the national government of Liechtenstein, the principle of sustainability relates to the "provident use of resources and maintenance of a high quality of life" (Fl, 2010b, p. 11). Climate protection is a high political focus and sets the basis for action in Liechtenstein's environmental policy. Its climate policy integrates individual sectoral policies, in energy, environment, transport, agriculture and forestry, first introduced in 2007 via the Climate Protection Strategy (FL, 2007). Each area incorporates measures that plays a part in the reduction of greenhouse gases and works together to pursue climate objectives that are essentially based on those of the Kyoto Protocol, the EU, and Switzerland:

Table 16. National climate objectives.

Objectives	Policy influence	Baseline Year	Year Established
Reduce emissions >8% by 2008-2012	Kyoto Protocol (2004)	1990	Since 3 March 2005
Reduce emissions by 20%, 20% renewables in the energy mix, 20% improvement in energy efficiency, all by 2020	20-20-20 Climate and Energy Package (EU)	1990	Since March 2007
Reduce emissions by 20% by 2020	Copenhagen Accord (EU)	1990	Since 18 December 2009
Reduce emissions by 80-95% by 2050	Roadmap 2050 (EU)	1990	Since 15 December 2011

To meet the commitments of the Kyoto Protocol, the national government passed the Emissions Trading Act and the CO_2 Act:

The Emissions Trading Act (EHG) prioritises national emissions reduction measures before projects abroad, which are undertaken through Clean Development Mechanisms (CDMs) or international emissions trading. The Act also implements Directive 2003/87/EC (Emissions Trading Directive) into national law and obliges industrial installations in the country to participate in the European Emissions Trading Scheme.

The CO_2 Act, established in 2006, corresponds to the CO_2 Act of Switzerland. The Act is a result of a bilateral agreement between Liechtenstein and Switzerland on environmental levies within the Principality, and is essentially a tax on fossil fuel consumption in all sectors, from private households to industrial and business sectors. The Act emphasises the reduction of greenhouse gases and CO_2 emissions from the energy-related use of fossil energy sources of at least 10% by the year 2010 compared to 1990 levels. It essentially targets the efficient use of fossil fuels. The revenues are returned to the sectors (except to private households) by granting subsidies to employer obligations.

Although this tax in Switzerland uses part of the revenue to finance the thermal insulation for buildings program, proceeds in Liechtenstein go towards environmental policy measures since the country does not formally participate in the Swiss building program. Although the revenue from the tax was never originally earmarked for Liechtenstein's policy measures in energy efficiency and renewable energy, the latest Energy Strategy of 2012 indicate a possibility of introducing this scheme. Another important measure is "climate cent", which is a tax on engine fuel, applied since 2005. This measure is based on an agreement with the Swiss "Climate Cent Foundation", whereby revenues generated are reinvested into climate protection projects in Liechtenstein.

The customs and monetary agreements with Switzerland have impacted on the environmental strategies in Liechtenstein. Many Swiss taxes and regulations for special goods (for example, environmental, building and fiscal standards) have also been adapted and applied in the country. Liechtenstein also relies on its neighbour for climate reporting activities since it does not have the capacity to develop its own greenhouse gas inventory to a highly sophisticated level with country-specific methods and emission factors in every source category.

Table 17. National climate regulations.

Law	**Focus**	**Relevance to municipalities**	**Issue year**
Emissions Trading Act (EHG)	First and foremost national inland measures	No direct influence	2002
CO_2 Act	Levy on fossil fuel consumption	No direct influence	2008
Climate Cent	Levy on engine fuel	No direct influence	2005

Although international and regional agreements have undoubtedly influenced Liechtenstein's climate objectives, it could be argued that the conditions and benefits associated with their ratification have impacted the priorities in Liechtenstein over the years. For instance, when the allowable emissions budget was exceeded in 2008, the national government of Liechtenstein resorted to the purchase of several million francs worth of carbon credits to compensate for this surplus. Conditions of the Kyoto Protocol had allowed nations to make use of alternative mechanisms such as CDMs or carbon trading, to compensate for emissions surplus. It is arguable whether carbon trading actually results in any real, positive environmental impact, since the county in which emissions are compensated continue to emit as per usual, if not more (Wara & Victor, 2008). Still, the primary focus on carbon emissions reductions has positively influenced national energy policies, in terms of emphasising quality labels (e.g. Gold Standard, Social Carbon) by the National Climate Protection Strategy in 2007, and the stipulation of optimised energy efficiencies in the Energy Efficiency Act (EEG) in 2008. This has filtered through to the local level through local building codes promoting energy sufficiency and efficiency first, and then, encouraging the uptake of renewable energy.

In Liechtenstein, renewable energy does not have a specific national law of its own but is incorporated into the national Energy Efficiency Act (EEG, 2008). In this Act, there is no mention of using renewable energy as a means to gradually replace nuclear or fossil energy use, instead it focuses primarily on its promotion and subsidisation in building renovations and awareness-raising.

Development of national energy policies and strategies

The following national laws constitute the legal framework for the promotion of energy efficiency and renewable energy through building and spatial planning in Liechtenstein, in chronological order:

Table 18. The legal framework for energy efficiency and renewable energy (Translated and adapted from http://www.gesetze.li).

Law	Focus	Relevance to municipalities	Issue year
Energy Certification Act, No. 190 (Energieausweisgesetz, EnAG, 2007)	Energy certification of buildings for sale, rent or lease.	Function, age and condition of the buildings need to be ascertained by the municipality.	27 July 2007
Energy Regulations, No. 222 (Energieverordnung, EnV, 2007)	Minimum requirements for energy-saving design and management of buildings; and the technical requirements on the energy performance of buildings and their energy improvement potentials.	Required energy performance reporting enables municipalities to assess installations that are applying for municipal subsidies.	24 August 2007
Energy Efficiency Act, No. 116 (Energieeffizienzgesetz; EEG, 2008)	The organization of contributions for support measures to increase energy efficiency and increased use of renewable energies; the purchase and payment of electricity from renewable energies and cogeneration, and the imposition of a levy on feed-in electricity.	Municipalities are entitled to refer to the national Energy Office when advising private individuals, institutions and communities in all aspects of efficient and environmentally friendly use of energy and the use of RES.	30 May 2008
Energy Efficiency Regulations, No. 118 (Energieeffizienzverordnung; EEV, 2008)	Subsidy structure for energy efficiency and renewable energy.	Aids municipal assessment in building entitlements to municipal subsidies.	30 May 2008
Building Act, No. 44 (Baugesetz, BauG, 2008)	Regulates the construction, alteration, demolition, maintenance and the use of buildings and facilities with the aim to promoting settlement quality in the municipalities; and the orderly and efficient development of the ground state. Stipulates planning law (the structure plan (Richtplan); the Building Regulations (Bauordung) with the zone plan; the redevelopment plan (Bebauungsplan); the design plan (Gestaltungplan). Stipulates planning approval procedures.	The municipal building regulations, zoning plan, redevelopment plan and design plan is the responsibility of the municipality (changes subject to national government approval).	29 January 2009
Building Regulations, No. 240 (Bauverordnung, BauV, 2009)	Regulating the content of zones, redevelopment and design plans; the building code requirements for buildings and facilities; building permits and notification procedures; collection of construction statistics data; fees.	Municipalities must adhere to this framework.	25 September 2009
Amendment of the EEG, 2008, No. 164	PV systems with a maximum of 40-kilowatt DC electric power, conveyor contribution are raised from CHF 650 to CHF 1000 per kilowatt of installed DC power is aligned, feed-in tariff rate 55 to 45 rap/kWh.	Municipal awareness when advising new developments.	11 June 2010
Amendment of the EEV, 2008, No. 166	Conveyor contribution is raised to CHF 1500/kW.	Municipal awareness when advising new developments.	19 June 2010

The impact of these laws on municipalities is significant because they require local authorities to be acquainted with the concepts of energy performance, energy efficiency, and renewable energy when granting energy certification, building approvals and municipal subsidies. A heightened degree of understanding of the technology, their systems, installation and how electricity is priced, certainly amongst those directly responsible for local building, infrastructure and planning, was essential. Establishing a close working relationship with the national energy office therefore has also been paramount, as municipalities have had to keep up-to-date with the latest news on technologies and revisions to energy and building regulations, particularly the feed-in tariff scheme, as renewable electricity prices had gradually diminished over a period of five years. As the titles of the laws suggest, the focus has been primarily on regulating the energy performance of buildings, and the subsidising of renovations with regards to insulation, followed only by renewable energy technology installations.

It is important to note that even prior to the abovementioned legislation, the national government of Liechtenstein has produced several energy concepts to help the country to come to terms with the rapidly changing priorities in energy: from energy sufficiency and energy security in the 70s and 80s, to energy efficiency and energy independence based on renewables from the 90s and onwards. The following table traces the priorities of every national energy plan since 1977 on energy efficiency and renewable energy in the Principality. It also includes the Renewable Liechtenstein study as an accepted strategy by the national government for comparison:

Table 19. Priority comparison across energy strategies over time. ES = Energy Strategy, RL = Renewable Liechtenstein, EC = Energy Concept.

	ES2020	**RL**	**EC2013**	**EC1988**	**EC1977**
Spatial planning					
Densification, compact settlements					
Reduced construction zone					
Favourable orientation					
Amendment of building or planning laws					
District heating					
Public transport					
Pedestrian and cycle network					
Carpooling					
S-Bahn					
Mobility management in companies					
Electric vehicles					
Prioritising of local products to reduce footprint					
Building					
Energy refurbishment of buildings					
Promoting an energy standard (e.g. Minergie)					
Individual heating bills					
Conserve the heat load: use of sunshields and plants for shading and cooling of facades.					
Replacing old systems with modern high-efficiency systems					
Wood pellet systems for space and water heating					
Heat pump for space and water heating					
Solar panels for water heating					
Regulations for new buildings					
Power efficiency in large buildings					
Energy performance certificate					
Low-interest loans for energy-saving measures					
Devices					
Minimum requirements for appliances, motors and					

	ES2020	RL	EC2013	EC1988	EC1977
lighting	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Efficiency measures in industry	Recommended	Recommended	Recommended	Recommended	Recommended
Use of waste heat in industrial expansion and heat networks	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
System of incentives for utilities	Recommended	Not mentioned	Recommended	Not mentioned	Not mentioned
Smart energy	Recommended	Not mentioned	Recommended	Not mentioned	Not mentioned
Energy storage	Recommended	Not mentioned	Not mentioned	Not mentioned	Recommended
Energy efficiency of public water supply and wastewater treatment	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Energy procurement					
Power generation from PV systems	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Power generation from CHP plants	Recommended	Recommended	Recommended	Recommended	Not mentioned
Power generation from small and medium hydro	Recommended	Recommended	Recommended	Recommended	Cursorily mentioned
Power generation from wind power	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Wood heating plant	Recommended	Recommended	Recommended	Recommended	Not mentioned
Biogas	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Natural gas	Cursorily mentioned	Cursorily mentioned	Cursorily mentioned	Recommended	Recommended
Geothermal power and heat	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Coal and peat	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Cursorily mentioned
Imports, mix and sourcing strategy	Recommended	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Energy awareness					
Energy Cities	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Education and training	Recommended	Not mentioned	Recommended	Recommended	Recommended
Research	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Publications, website, etc	Recommended	Not mentioned	Recommended	Recommended	Recommended
Energy Office/ Energy coaching	Recommended	Not mentioned	Recommended	Recommended	Recommended
Exemplary role of the public sector	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Supporting private initiatives (e.g. energy savings prize)	Recommended	Recommended	Not mentioned	Recommended	Not mentioned
Quality assurance for appliances	Recommended	Not mentioned	Recommended	Not mentioned	Not mentioned
Street lighting audits ("Lamp doctor")	Recommended	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Decision support					
Energy statistics	Recommended	Recommended	Recommended	Recommended	Recommended
Energy efficiency potential studies	Recommended	Recommended	Recommended	Recommended	Recommended
Renewable energy potential studies	Recommended	Recommended	Recommended	Not mentioned	Not mentioned
Assessment of government state activities	Recommended	Recommended	Recommended	Recommended	Not mentioned

Recommended Cursorily mentioned Not mentioned

Table 19 shows that spatial planning played a significant role in the early energy concepts of 1977 and 1988. It was an aspect that was seen to have potential influence on energy consumption and energy efficiency in the country. Due to the lack of building guidelines targeting energy generation at the time, the early energy concepts preferenced spatial planning rules that could encourage densification through compacting settlements and reducing construction areas, creating district heating zones, and orientating buildings favourably to optimise passive solar gain. Indeed the Building Act of the time did not include any provisions, which regulated the security of the energy supply or the control of energy consumption. When the 1977 concept was released, the Law on the Promotion of the Construction of Private Homes (Law Gazette 1965 No.1) was the only legal code available that could promote energy efficient building. The law stipulated recommendations for the construction of row housing in order to save energy in building construction and maintenance. But despite the potential to optimise energy efficiency in the use of these buildings, it has been argued that the law was intended more as a means to encourage compact development in order to save space, and improve walkability and accessibility (Energy Commission, 1988).

However since the energy concepts of 1977 and 1988, the focus on spatial planning had diminished considerably. There was no action even by 1993, when the first heating and insulation requirements in buildings were introduced. By the time the Energy Concept 2013 was released in 2004, there was no longer any mention of spatial planning. The focus had shifted from the concepts of compact settlements or district heating zones to individual buildings and energy technology. Unlike the preference for more compact row housing in earlier building regulations, by the time the Building Act was revised in 2009, there was no mention of a preference for any particular building type at all. Rules would only govern heights, lengths, distances between buildings and to boundaries, and density, all depending on the zone function. It is interesting to note that energy storage, which was first discussed in the 1977 energy concept also suffered a hiatus for over 30 years, until it was picked up again in the Energy Strategy 2020 in 2012.

As for the role of local government, their role has significantly improved over the 40-year period since the first energy concept, although some traditional assumptions still exist in terms of their perceived interest and capacity. The following table notes key focus and measures of each strategy, and the implications these have had on local government engagement and action:

Table 20. The non-statutory measures and relevance for municipalities.

Strategy	Focus	Relevance to municipalities	Issue year
Energy Concept 1977	**13** measures to achieve energy efficiency and security of supply. Key targets: Independence from imported energy (security of supply), alignment of energy needs, diversification of energy carriers, limiting energy consumption, compliance with environmental protection requirements, energy efficiency.	No reference to municipalities.	1977
Energy Concept 1988	**14** measures to maintain adequate energy supply, matching energy with economy and personal needs, while protecting the environment. Key targets: Energy savings in buildings (modern heating technology, controls, insulation, renovation campaign, training, amendment of the construction act, an energy unit for energy consulting); spatial planning principles (densification of construction, compact settlements, expansion of pedestrian and cycling networks, improved public transport); exploit combined heat and power plant (CHP) potential; expansion of hydropower on the Rhine; efficient natural gas supply to maintain a diverse energy mix; energy cadastre for precise info on actual energy savings potential; complementary environmental and energy policies to address emissions.	Action analysis of typical building types and their energy savings potential will require both municipal and national government cooperation, especially with regards to public buildings. Improvement of infrastructure for expansion of energy network will also require municipal support. Municipalities should be given proper advice by qualified specialist on a permanent basis, who should also coordinate all projects and energy carriers. Municipalities and the national government must consider different financial arrangements to promote energy efficiency measures.	1988
Energy Concept 2013 (Energiekonzept 2013)	**17** measures to support the promotion of efficient energy use, the use of renewable energies, and energy conservation. Key targets: Increase the share of renewable energy in total energy use from 8% to 10% by 2013; reduction of heat loss through thermal	Relevant performance targets for municipal assessments in municipal energy subsidy applications. Measure No. 17 specifically encourages the existing involvement of Liechtenstein municipalities in the Energy City	2004

Strategy	Focus	Relevance to municipalities	Issue year
	refurbishment using Minergie standards; triple the use of solar energy through thermal solar panels; increase the production of electricity from solar energy through PV systems by a factor of 2.5; investing in cogeneration plants in large projects (primary and secondary heat power generation); increased use of domestic wood as an energy source; and information and incentive policy offensive via the National Energy Office.	program, requiring performance audits and reporting to maintain the label.	
Energy Strategy 2020 (Energiestrategie 2020)	**47** measures for a safe, sustainable and affordable energy services. Continues Energy Concept 2013 efforts + analyses its achievement to identify key developments and potentials. Key target: the stabilization of the total energy demand, increasing the proportion of local renewable energy to 20% and a reduction of greenhouse gas emissions by 20% compared to 1990	Designated **3 (of 47)** areas of responsibility: Slow and active transport (with national government); energy efficient public water supply and sewage system (incl. use of waste heat, biomass heat); contributions to a countrywide energy cadastre. The continuation of the Energy Cities program is the responsibility of the national government.	2012

Table 20 shows that the role of local governments in the development of each national energy concept has been minor. Over the years, the concepts have generally focused on their entitlement to advice or subsidies from the national government via the Energy Office. Municipal responsibility remained through their continuing participation in the Energy City program. It is only in the latest Energy Strategy 2020 (Energy Commission, 2012) which finally expanded the number of municipal responsibilities to include continuing the promotion of the 'Slow and Active Transport' program; implementing greater efficiency measures within the municipal public water supply and sewage system, including the capture of waste heat for local district heating; and contributing towards a country-wide energy cadastre based on the submission of individual municipal cadastres.

As described earlier, the role of spatial planning has diminished considerably and has not been used by the central government to optimise energy efficiency and renewable energy integration through area-wide strategies that could in turn influence local government's own spatial planning practices.

National spatial planning and mobility policies

The national spatial planning tool governing urban development in Liechtenstein is the National Structure Plan (Landesrichtplan). It exists as a non-statutory guide and sets several important spatial parameters. These refer to the efficient use of land; the preservation of natural and cultural landscapes from urban sprawl; the securing of agricultural land-use; the densification of settlements with high quality housing; the securing of the country's water, energy supply and sites tor waste disposal and treatment; the definition of paths for main roads; the encouragement of a reliable and effective integrated transport system; the maintenance of areas for industry and commerce that is properly connected to the road and rail network; the access to international long distance transport networks; and the adaptation of areas against flooding and natural hazards.

Municipalities are encouraged to fit their own municipal plans according to the recommendations of the National Structural Plan, but they are not legally bound to do so.

The first National Structural Plan was created in 1968, the result of the national government engagement with the Institute of Local, Regional and National Planning of the ETH in Zurich, Switzerland to work out a report on spatial development in Liechtenstein. The content of the plan would be non-binding and used only for administrative purposes. Indeed, this early plan was overall reactionary and possessed very low levels of influence. It accounted for urban development as they occurred and the plan would be adapted according to these changes. Its limited role continued throughout the 1980s until 1988 when there was a call to make the Plan a statutory planning tool. However by 2007, when the national government took notice of the Plan and began integrating the mobility concept it had by then conceived, the Plan remained a non-statutory item. In 2009, the plan was revised to anchor it into the national Building Act, but this was not approved until 2011. In 2012, a supporting handbook and appendix to the Structural Plan finally articulated the functions of the Structural Plan in detail. It defined the terms of application, responsibility, revision, administration and management. This process however was postponed when a major restructuring in 2012 of the national government ministries and departments took place, significantly impacting the departments responsible for spatial planning. In 2013, the Structural Plan was abandoned as a national planning tool, a direct consequence of the restructuring process and a tightened national budget.

The Spatial Planning Office (Stabstelle für Landesplanung), the department responsible for the National Structure Plan, was dismantled at the beginning of 2013 and divided into two competencies: the Department of National Planning and the Department of Local Planning. Both departments now reside under the new Ministry of Infrastructure, Environment and Sport, with the local planning department further embedded within the new Office of Construction and Infrastructure, but under the same ministry. The national planning department deals with the development and support of the country’s Structural Plan and manages regional and trans-national spatial issues. The local planning department handles the needs of the municipalities and their compliance with national policies on sustainable spatial development. The latter also assesses the planning instruments of the municipalities and sets applications for planning approvals by the local government. The local planning tools monitored include:

- The municipal structure plan (Gemeinderichtplan), which defines the development zones,
- The municipal building code (Gemeindebaurordnung), which describes the general design and construction requirements of the municipality and the provisions of the municipal zone plan,
- The zoning plan (Zonenplan), which divides the municipality into different construction zones and other zones use and is an integral part of the building code,
- The redevelopment plan (Uberbauungsplan), which determines the superstructure of special areas such as a neighbourhood in addition to the building regulations, and
- The design plan (Gestaltungsplan), which regulates redevelopment in greater detail.

Before its abandonment, the National Structural Plan had long been criticised for being weak and to lack vision. According to a former director of the spatial planning department, the Plan was “quite vague in many aspects”… more possibly a result of a “compromise to reflect the status quo”. Although the Structural Plan was able to integrate the interests of a range of stakeholders, including local governments, the process ultimately led to a conciliated approach. According to the former director, “decision-making was very difficult because no ‘crucial votes’ were allowed.” Consequently, the Structural Plan became largely an inventory of existing conditions rather than a future vision. It did not propose any strategic measures since it did not delineate any goals or targets to aspire to.

Energy was referred in the Structural Plan under the theme of “Supply and Disposal”, which recommended the promotion of renewable energy use and the allocation of land for renewable energy production (FL, 2011). However, on closer review, only waste disposal, sewage treatment and water networks were articulated in its large-scale map. There were no areas denoted for renewable energy generation, or areas marked with the potential for future renovation or energy improvements. Although the Structural Plan overall aimed to support the use of renewable energy sources and the optimisation of energy efficiency, it did not recommend any spatial strategies to achieve these goals. According to the former director of the (former) spatial planning department, there was a potential to integrate energy aspects into the Structural Plan but no solution was found as to how this would be achieved.

In relation to the municipalities, the Structural Plan had little or no influence on local planning. The preferred focus of the Plan was rather on large-scale infrastructure *projects* such as the proposed development of the S-Bahn (overland train line extension) and the new urban development in Nendeln. According to the Liechtenstein Association for Environmental Protection (LGU), the Plan did not provide guidance for municipal planning and really only served as tool to retain open space for infrastructure projects. It was a conservative territorial approach, which did not focus on the process, innovation or supra-regional coordination. Furthermore, it provided no concrete contribution to sustainable spatial development (Liechtensteinische Gesellschaft für Umweltschutz [LGU], 2006). Another criticism related to the failure to integrate existing spatial planning measures that already existed in the region, and the failure of those responsible for the Plan to use it as an illustration of an alternate future vision for the Principality. The Liechtenstein Traffic Club (Verkehrs Club Liechtenstein) described the Plan as non-committal and non future-oriented, failing to set spatial strategies that actually attempt to address existing problems or anticipate future ones. The Club cited the failure to consider mobility recommendations that were already set by the “Agglomerationsprogramm Werdenberg-Liechtenstein” (Kantons St. Gallen, 2007). According to the Club, the Structural Plan has focused more on allocating corridors for bypass roads – a measure, which actually makes private transportation even more attractive – rather than on localised strategies to reduce traffic (Verkehrs Club Liechtenstein [VCL], 2011).

In contrast, the national mobility concept (Mobilitätkonzept Mobiles Liechtenstein 2015) was a strategy that specifically addressed localised strategies for municipalities that impacted local energy consumption. First introduced in 2008, the goal was to reduce consumption of fossil fuels in vehicles. This required energy efficiency improvements in the overall public transport system such as the expansion of the Liechtenstein Bus Authority; the creation of the "Liechtenstein Takt" regional train schedule between Liechtenstein and Austria; the preferential treatment of buses at traffic lights; subsidies for electric scooters and electric bicycles; and security measures for schoolchildren and other localised mobility campaigns (FL, 2008). In transitioning to renewable or less-polluting fuels, the concept recommended tax exemptions for solar, electric, hybrid, and natural gas vehicles. All measures were to be partially financed by revenues from the Heavy Vehicle Fee (2001) applied to vehicles of a certain weight and above, differentiated according to the distance driven. The fee aimed to shift heavy goods traffic from road to rail and give the carriers an incentive to purchase the most modern vehicles and to use them more efficiently. Interestingly, most of the measures above have been adopted by the municipalities. However one deficiency lies in the lack of focus on renewable fuels, which was not a consideration for the national government when formulating the concept.

With regards to local government involvement, the mobility concept stipulated consistency in municipal participation until 2015 and beyond. Indeed, since its creation, its recommendations have been adopted either fully or partially by most of the municipalities, augmenting traditional mobility efforts such as creating better pedestrian walkways, cycleways, and traffic calming measures through ‘Slow-Zones’. It is not known whether the mobility concept has created a significant impact on the overall vehicular energy consumption in the Principality given the growing resident population and presence of commuter traffic. However the success of many measures prescribed by the mobility concept has prompted their continuation in the current national energy strategy.

Energy Strategy 2020 (Energiestrategie 2020 - ES2020)

In 2012, ES2020 was released stipulating 47 recommended measures predicated on achieving safe, sustainable and affordable energy services in Liechtenstein. The 47 measures aimed to meet key energy targets by 2020, based on stabilizing the total energy consumption through a 20% increase in energy efficiency, increasing the proportion of local renewable energy to 20%, and reducing greenhouse gas emissions by 20% compared to 1990 levels. This *stabilised* energy consumption scenario was considered most appropriate given the need to counter the growing ‘rebound effect’ in energy consumption due the growth in the economy and population, and the use of energy efficiency and renewable energy technologies available at the time. Contrasted against the ‘Business-As-Usual’ scenario, which was considered insufficient to achieve the nominal 20-20-20 targets set by the EU, and against the 100% self-sufficiency target as demonstrated by the Renewable Liechtenstein study, thought to be very costly, forceful and potentially harmful to the local environment, while also engendering community and political opposition, the stabilised consumption scenario, was seen to be the most adaptable to changes in the economy, community perception and evolving technologies (Energy Commission, 2012). Of the 47 measures, 3 were designated specifically as a local government responsibility: low and active transport (along with the national government), energy efficient public water supply and sewage system (including use of waste heat, biomass heat), and contributions to a countrywide energy cadastre. The continuation of the Energy Cities is stipulated as a task for the national government.

It is important to note that ES2020 continues the Energy Concept 2013 (EC2013) efforts particularly the measures that were succcessful between the period 2003 and 2013, while also includes strategies to address the measures that failed. Those achievements include: conducting thermal renovations in the building stock by 6%, increasing the share of renewables in the total energy consumption to over 10% by 2013 (including imported renewables), tripling the use of solar energy through solar thermal systems, increasing the production of photovoltaic electrical energy by a factor of 2.5, disseminating information and motivation activities via the Internet, media and Energy Office, increasing the use of wood, promoting home automation systems, promoting the energetic use of groundwater heat, monitoring public building energy, creating support mechanisms for communities for Energy City participation, and developing an energy R&D platform through the Department of Economy. Measures not achieved within the period included: reducing greenhouse gas emission by 8% over the 1990 level, reducing energy increases by implementing Minergie standards for new buildings, increasing investment in cogeneration (CHP), expanding biogas production, adoption by the public of the ‘Traumhaus –Althaus’ scheme as a platform for the ecological and energy optimisation in the renovation of old buildings, offering cooperation schemes for companies to increase efficiency and the use of RES, and promoting the energetic use of the River Rhine (Energy Commission, 2004).

It appears that the measures that did not succeed were those that could not cope with increased energy use, could not withstand low fossil fuel prices, were not supported by incentives, and were related to newer, advanced technologies at a scale that the municipalities of Liechtenstein were not traditionally accustomed to. The latter measures in particular required a higher level of understanding for their acceptance and implementation, and moreover time. Unlike the direct energy generated and monies earned from a PV panel, these measures did not demonstrate direct energy or economic savings to the consumer. Several steps in their planning, construction and distribution process are required until the energetic gains are known to the consumer. ES2020 attempts to address this aspect through the specific targeting of stakeholders who can handle specific energy efficiency and RES technologies in relation to the 47 measures, thereby achieving the energy targets of 20-20-20.

In 2014, the national government proposed changes to the Energy Efficiency Act (2008) in order to implement the ES2020. However the Liechtenstein Solar Cooperative has since found that these changes were insufficient to achieve the Strategy’s 20-20-20 energy targets initially proposed. Based on their own evaluation, less than 40% of the 20-20-20 target would be achieved by 2020 according to the proposed changes in the EEG law (LS, 2014). The small changes was argued to be more the result of efforts to reduce the national budget, rather than to transform the future energy supply of the country: “it is a politics of small steps which will increase the import dependency of the country and therefore the national economic risks” (LS, 2014). Their evaluation indicated that extent of changes to the law signalled only a moderate, not full, commitment to ES2020. In response, the

Cooperative proposed several solutions to counter the effect of a dwindling national budget on the implementation of ES2020: setting a definite price for fed-in renewable electricity, ceasing of CO_2 certificate purchasing with no more subsidies to industry, using the carbon tax to finance the ES2020 measures. The Cooperative also recommended the adoption of similar planning rules to that of the spatial planning law of Switzerland. Article 18a in particular states that in all buildings and those in agricultural zones, plans for sufficiently adjusted adapted solar installations do not require any permits but must be reported to the local planning office. Also, the use of solar energy on existing or new buildings is in principle considered superior than any aesthetic consideration (Spatial Planning Law – RPG, 2012). Based on the tradition of bilateral cooperation, there is great potential (and likelihood) for the national government of Liechtenstein to also adopt these rules.

Strong national policies will be required to implement all 47 recommendations of the ES2020. Long-term motivation and consistency in implementation will be critical to achieve the energy targets, particularly if these form the basis of pursuing energy autonomy in the Principality.

It is important to note that when the ES2020 targets and its recommended measures were compared with those of the Renewable Liechtenstein (RL) study, it was found that these were actually complementary, or even exceeded those of RL. In short, ES2020 is theoretically in line to achieve energy autonomy (see Table 21). The efficiency measures were more ambitious while the renewable energy generation even exceeded the innovation scenario of RL (see Table 22). However, this assumes that all recommendations are implemented.

Table 21. Comparison of Energy Strategy 2020 (ES2020) with the reference (RL-R) and innovation (RL-I) scenario of the Renewable Liechtenstein (RL) study.

	Measures	**Current**	**2020 target**	**2050 target**	**Maximum potential**
	Energy efficiency (GWh/a)				
ES2020	-20%	1390 GWh/a	1390 GWh/a	-	-
RL-R		1516 GWh/a	1419 GWh/a	1216 GWh/a	-
RL-I		1516 GWh/a	1319 GWh/a	859 GWh/a	-
	Renewable energy (GWh/a)				
ES2020	+20%	114 GWh/a	278 GWh/a	-	-
RL-R		152 GWh/a	190 GWh/a	305 GWh/a	-
RL-I		152 GWh/a	251 GWh/a	542 GWh/a	-
	Carbon emissions reductions (Gt CO_2 eq/a)				
ES2020	+20%	262 Gt CO_2 eq/a	184 Gt CO_2 eq/a	-	-
RL-R		357 Gt CO_2 eq/a	375 Gt CO_2 eq/a	370 Gt CO_2 eq/a	-
RL-I		357 Gt CO_2 eq/a	301 Gt CO_2 eq/a	148 Gt CO_2 eq/a	-
	Efficiency measures (GWh/a)				
ES2020	Building renovation	-	37.5 GWh/a	-	250 GWh/a
ES2020	Promotion of Minergie standard	-	4.4 GWh/a	-	50 GWh/a
ES2020	Increase efficiency of heating systems (heat pumps geothermal energy)	-	49.8 GWh/a	-	115 GWh/a
ES2020	Regulations for new buildings	-	7.2 GWh/a	-	7.2 GWh/a
ES2020	Electricity efficiency in large buildings	-	1.6 GWh/a	-	1.6 GWh/a
ES2020	Replacement of circulation pumps	-	1.4 GWh/a	-	1.4 GWh/a
ES2020	Public transport	-	5 GWh/a	-	112 GWh/a
ES2020	Mobility management in companies	-	4.5 GWh/a	-	51 GWh/a
ES2020	Electric vehicles	-	12.5 GWh/a	-	175 GWh/a
ES2020	Minimum requirements for appliances, motors and lighting	-	27 GWh/a	-	52 GWh/a
ES2020	Efficiency measures GE/I	-	37.5 GWh/a	-	84 GWh/a
ES2020	Use waste heat / FW network expansion	-	9 GWh/a	-	40 GWh/a
ES2020	Incentive system utilities	-	47.5 GWh/a	-	79 GWh/a
ES2020	CHP plants	-	5.7 GWh/a	-	12.5 GWh/a
ES2020	Quality heat pumps, turbines	-	2.4 GWh/a	-	5.8 GWh/a
ES2020	Replacement of old household appliances, on-site consulting	-	9 GWh/a	-	9 GWh/a
ES2020	Lamp doctor	-	9 GWh/a	-	9 GWh/a
Total		1390 GWh/a	**1390 GWh/a**	-	617.5 GWh/a
RL-R		1516 GWh/a	1419 GWh/a	1216 GWh/a	-
RL-I		1516 GWh/a	1319 GWh/a	859 GWh/a	-
	Renewable energy (GWh/a)				
ES2020	Geothermal	0 GWh/a	0 GWh/a	-	0 GWh/a
RL-R		15 GWh/a	34 GWh/a	93 GWh/a	-
RL-I		15 GWh/a	59 GWh/a	130 GWh/a	-
ES2020	Solar thermal	8 GWh/a	21 GWh/a	-	36 GWh/a
RL-R		8 GWh/a	15 GWh/a	25 GWh/a	-
RL-I		8 GWh/a	19 GWh/a	33 GWh/a	-
ES2020	Photovoltaics	6 GWh/a	27 GWh/a	-	104 GWh/a
RL-R		1 GWh/a	10 GWh/a	32 GWh/a	-

	Measures	Current	2020 target	2050 target	Maximum potential
RL-I		1 GWh/a	18 GWh/a	70 GWh/a	-
ES2020	Water	70 GWh/a	153 GWh/a	-	237 GWh/a
RL-R		72 GWh/a	72 GWh/a	72 GWh/a	-
RL-I		72 GWh/a	85 GWh/a	124 GWh/a	-
ES2020	Wind	0 GWh/a	3 GWh/a	-	10 GWh/a
RL-R		0 GWh/a	0 GWh/a	0 GWh/a	-
RL-I		0 GWh/a	8 GWh/a	16 GWh/a	-
ES2020	Deep geothermal	0 GWh/a	23 GWh/a	-	75 GWh/a
RL-R		0 GWh/a	0 GWh/a	0 GWh/a	-
RL-I		0 GWh/a	0 GWh/a	125 GWh/a	-
ES2020	Biomass	48 GWh/a	104 GWh/a	-	104 GWh/a
RL-R		54 GWh/a	56 GWh/a	68 GWh/a	-
RL-I		54 GWh/a	56 GWh/a	58 GWh/a	-
ES2020	Total	132 GWh/a	**330 GWh/a**	-	104 GWh/a
RL-R	Total	150 GWh/a	187 GWh/a	290 GWh/a	-
RL-I	Total	150 GWh/a	245 GWh/a	566 GWh/a	-

Table 22. Share of renewable energy in 2020.

ES2020	23.7%
RL-R	13.2%
RL-I	18.6%

National players

It is important to note the major national players who have had a significant influence on the ability of local governments in Liechtenstein to implement energy projects on their accord. They can be divided into three types: *the legislative, the utility and the cooperative*. The legislative refers to the national government ministries and their relevant departments and offices dedicated to energy. The utility refers to the national electricity and natural gas suppliers. The cooperative refers to development or community associations, which sometimes incorporate the national government, local government and private enterprise, as shareholders for carrying out research and pilot projects in energy across the Principality.

Energy supply, pricing, monitoring and legislation are governed predominantly at the national level via two national ministries (Ministry of Internal Affairs, Justice and Economy and Ministry of Infrastructure, Environment and Sport). The bulk of responsibility for development and implementation of the national energy strategies is maintained by the Ministry of Internal Affairs, Justice and Economy via the Energy Office (Energiefachstelle), and advised by the Energy Commission (Energiekommission). In terms of spatial planning, the national and local planning departments reside within the Ministry of Infrastructure, Environment and Sport. The national government cooperates closely with the two national energy providers, Liechtenstein Power Company (Liechtensteinische Kraftwerk - LKW) and the Liechtenstein Gas Supply Company (Liechtensteinische Gas Vorsorgung - LGV). Compared to the LKW and LGV, which essentially operate as private, nationally-owned companies, local governments can wield influence through two community associations: the Wastewater Association of Liechtenstein Municipalities (AZV) and the Liechtenstein Solar Cooperative. All of the municipalities of Liechtenstein have economic stake in both entities, as shareholders, managers or clients.

National energy commission

The concept of an energy commission was first introduced in the first national energy report of 1977, when it was proposed that leadership in energy that represented the different sectors of the economy was needed in order to formulate a new energy concept that addressed energy efficiency and energy security in Liechtenstein. However, it was not until 1986 when the first formal working group for energy was established. Since then, the energy commission has evolved, and finally institutionalised in 2008 (EEG, 2008, Art.20-21) as part of the Energy Efficiency Act. Today, the Energy Commission advises the national government on energy policy and provides expert feedback on all questions of energy policy. The make-up of the Commission includes experts from all the relevant areas, such as architecture, energy, industry, trades, administration, and environment.

National energy office

The Energy Office (Energiefachstelle) was also formalised under the Energy Efficiency Act (EEG, 2008, Art.22). Its tasks include " implementing the decisions made by the Energy Commission; guaranteeing and distributing subsidies; drawing up strategic policies; elaborating energy-relevant laws or guidelines; addressing international agreements (e.g. EEA) which deals with the energy; advising individuals, local governments and institutions on planning matters concerning efficient and environmentally friendly use of energy; informing the public about energy efficiency and the environmental-friendly use of energy; coordinating and cooperating with governmental offices and affiliated organizations; providing training and further education of specialized personnel; certifying 'Minergie' rated buildings; and participating in other commissions and teams." (Translated from EEG, 2008, p. 13). The task of the National Office is to implement the recommendations set by the Energy Commission. It does not have legislative power to enact energy policies, which is the task of the Commission. However, it does have a large influence on the technical and logistical aspects of energy efficiency and renewable energy technologies, therefore impacting greatly on the preference for particular systems and networks when advising the Energy Commission and the municipalities.

Liechtenstein Power Company (LKW)

By law, the LKW is responsible for "maintaining secure energy supply for the Principality by producing, purchasing, transmitting, distributing, selling and trading electrical energy at home and abroad; and to provide a network infrastructure to maintain electronic monitoring and communication" (Translated from Law on Liechtenstein Power Supply Company [LKWG], 2009, Art.3, p. 2). Since its foundation in 1923, LKW has purchased the bulk of electricity from AXPO AG, formerly known as the Northeast Switzerland Power Company (Nordostschweizerischen Kaftwerke AG, NOK). In 2013, it is also a customer of the Berner Kraftwerken and Vorarlberger Kraftwerken. The LKW maintains overall control of the supply and grid structure, which local governments are connected to. There are few opportunities for the municipalities to participate in the regulation of the country's energy supply, or to give feedback, except for special energy contracting arrangements for electricity fed-in to the national grid. The LKW is not bound by law to create platforms for public engagement. The only time the municipalities are mentioned in LKW Act is with regards to maintaining the right of access to local water supplies by the communities when hydropower works are in place. LKW's policy on renewable energy focuses on increasing the proportion of electricity from indigenous renewable sources, deploy energy efficient street lighting, introduce smart metering and participate in wind farms in the North Sea. In 2012, LKW began providing LiStrom Natur, which is a standard electricity service product for residential customers. At the time, a levy of 0.2 Rp/kWh was remunerated on electricity generated from renewables and CHP plants.

Liechtenstein Gas Supply Company (LGV)

The Liechtenstein Gas Supply Company is also bound by law to “secure the supply of gas by supplying customers in the country with natural gas; create, operate and maintain equipment and facilities related to the distribution and supply of the necessary gas; purchase gas by contracts and other arrangements, and participate in the activities at home and abroad” (Translated from Law on Liechtenstein Gas Supply Company [LGVG], 1985, Art.2, p. 2). The Act does not include any provisions related to local government in Liechtenstein. LGV is however gradually positioning itself as a *heat* supplier rather than just as natural gas supplier, through developments in cooperation with municipalities. Examples include the CHP plants in Triesen and in Schaan, which is the largest heating network in Liechtenstein with almost 50 households connected, and the new biogas plant to be built in Bendern, in cooperation with the Wastewater Association of Liechtenstein Municipalities (AZV). They are also involved in discussions concerning other potential projects such as the new CHP plant in Balzers, and the re-use of waste heat from the waste incineration plant in Buchs, Switzerland.

Wastewater Association of Liechtenstein Municipalities (AZV)

The AZV was founded in 1971 but did not begin operations until 1976 in ARA Bendern. Its foundation meant the development of a complete sanitation plan for the entire country that met the demands of a growing population and expanding industry and that integrated gradual increases in efficiency standards in order to save energy and costs. The municipalities have banded together as a society (Verbandsgemeinden) to regulate this Association, with each mayor as delegates with voting rights to ensure the correct management of wastewater treatment for their community, but within the context of the entire Principality.

Liechtenstein Solar Cooperative

As described earlier, the Solar Cooperative includes the municipalities as well as local private companies and the national government as shareholders. It was responsible for the implementation of five major PV projects in the Principality: namely the installations on the primary schools of Triesen and Mauren, the installations on two bridges crossing the River Rhine, and in cooperation with LKW and the municipality of Vaduz, an installation on the Rhine Park Stadium. According to their Statutes, the Cooperative “aims to promote renewable energy through promoting the installation and operation of facilities for the use of renewable energy, to advocate the use of renewable energy by the public, and to inform the public about the use of renewable energy” (Translated from LS, 2012, Art.2, p. 1). To date, it has been active in 9 research projects on wind power in the Principality.

Liechtenstein Engineers and Architects Association (LIA)

The Association supports the interdisciplinary cooperation in the areas of construction, technology and environment. The Association establishes contact and provides information between the single registered members, the national authorities and the public. It is supported by the Liechtenstein building department and by ‘eco-bau’, a swiss platform for sustainable planning and constructions. Their aim is to develop and distribute planning tools for sustainable, ecological and healthy building strategies.

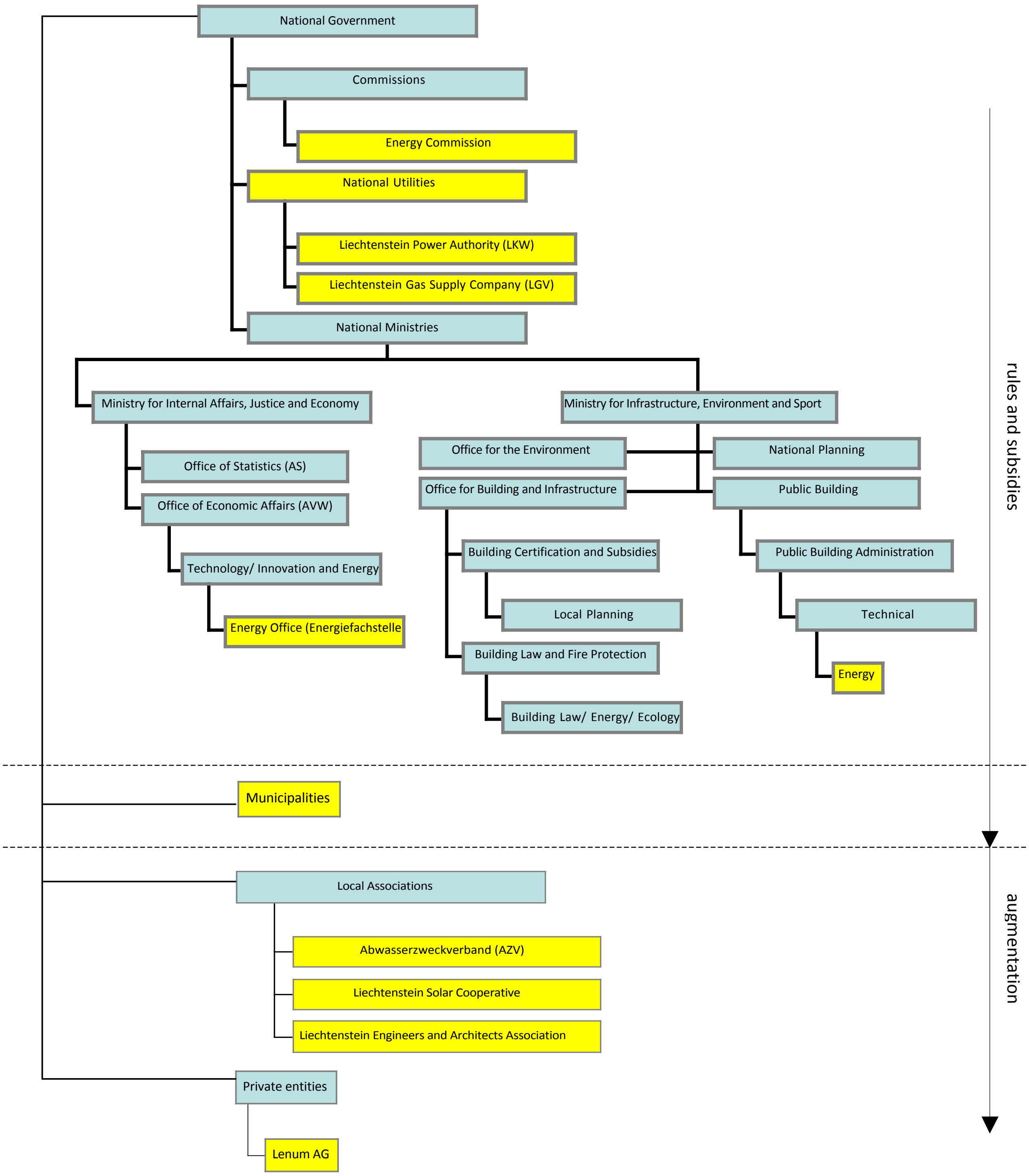


Fig. 122. Organigram of players directly associated with energy policy in Liechtenstein (boxes in yellow).

The organigram shows that the national Energy Office (Energiefachstelle) does not have the highest executive standing. It is answerable to the Ministry, and the Energy Commission, the latter of which sits higher in the national government hierarchy and is able to inform and advise the ministry and parliament more directly. As for spatial planning and building, the departments for national planning and local planning are embedded under a separate ministry, with no direct links to the national energy office. There is no direct relationship between the national planning department and the local planning department either. Local planning is dealt as a building certification and subsidy issue, close but not connected to the office of building law, energy and ecology. Building energy is treated under the separate area of building law and fire protection.

Distancing

In the energy autonomy case narratives, the national governments frequently took a step back and allowed localities to pursue their own visions and goals. 'Distancing' is difficult to achieve in Liechtenstein because the country is very small. Often, government officials share several roles through different departments and commissions. "Due to the short "distances" within the administration and due to a high degree of acquaintance between the persons involved, not every process, data flow and arrangement has needed to be established by a formal agreement" (FL, 2010, p. 56). At the local level, mayors and councillors have family members who also work within the national administration but who also participate in local community groups and different non-government associations in Liechtenstein. As a consequence, national and local issues permeate national and local discussions and influence priorities at all levels.

In the case of Liechtenstein, it is not useful to discuss the notion of distancing, that is, it is not a question of stepping back or devolving responsibility as much as increasing the level of trust by the national government administration in more ambitious local government pursuits. There is an inherent lack of trust shown in the manner in which the existing framework allows for municipal and community involvement. This is shown in the rudimentary nature of local government responsibilities and tasks outlined in the Local Government Act, the basic planning and building codes at the disposal of the municipality, and the exclusive control of energy by the national electricity and gas providers.

The energy autonomy cases showed that the ability of the national government to 'step back' while providing the necessary legal and financial framework for local governments to pursue energy projects was vital to their success in achieving energy autonomy. This 'distancing' enabled the councils to innovate, without the anxiety of possible legal restrictions, and free to embrace partners or stakeholders that were closer to the municipalities, such as local companies, farmers, residents and other community groups. The legal framework to allow local governments to create their own energy services companies, in the case of Wildpoldsried, the Village Development Company (Dorfentwicklungs GmbH), in Güssing, the EEE Association and in Samsø, the Samsø Energy Company and Samsø Energy Academy, was vital to their ability to implement a range of community energy projects.

In comparison, the municipalities in Liechtenstein have access to no similar frameworks. Instead they are bound to the national electricity provider LKW for energy, with the municipalities having virtually no say in the energy supply, distribution or pricing. There is little to no possibility for direct participation. There are no instances where municipalities have created their own energy services company or agency, except for establishing contractual arrangements with the Liechtenstein Solar Cooperative and the LKW, to implement PV installations on roof of municipal buildings and other structures. In relation to the price of energy, changes in the availability and price of the feed-in tariff (regulated by the national authorities) have caused uncertainty in the adoption of PV systems by the municipalities and their communities. As a consequence, being subject to the legal changes and the manoeuvrings of larger stakeholders, outside of the municipality and beyond municipal control, has created a stagnant, restrictive environment for councillors. It is uncertain as to what will happen next and by whom (LKW, LGV, ARA or the national administration?). This has left local government with the resignation that it is best not to consider pursuits outside the normal municipal "servicing" mode in waste and water.

5.5 Discussion

5.5.1 Response to Research Question 4

Research Question 4 as formulated in Chapter 1 stated:

'With particular focus on urban planning, how can local governments effect the transformation of existing policies and frameworks in order to pursue energy autonomy?'

In Liechtenstein, municipalities can effect the transformation through the use of local planning tools, and through active engagement with the national government. Municipalities can formulate a local energy plan with energy autonomy not only as energy target but also in contributing to the community's identity. Their mayors and community leaders can promote the success of local energy concepts and activities and champion landmark projects. They can improve their knowledge on energy matters through professional development activities, and maintain the individuals and groups necessary to pursue energy autonomy. They can take advantage of their right to *municipal* autonomy that also extends to *energy* autonomy. They can also recognise that Energy City is just one step towards the target. They can modify existing land-use planning and building codes to integrate rules governing renewable energy technology installation, and create special guidelines for households, businesses and industry with regards to the technology in order to supplement existing codes. They can match national subsidies or augment them to encourage greater implementation. They can actively participate in the formulation of national energy strategies and engage with the national energy suppliers to carry out landmark projects. They can set up new partnerships with neighbouring municipalities on energy projects as well as extend existing partnerships with local energy and environmental associations. These are lobbying devices that local governments can use to encourage further legislative, financial or technical support from the national level.

Clarifying terms and setting goals

The decision-makers workshop revealed that most officials were aware of the concept of energy autonomy and agreed that "it is right thing to do." However, there was an ambivalence as to whether this can be practically achieved due to the lack of available land, and the ease in procuring green power or investing in other forms of green energy abroad. There was also a confusion as to how energy autonomy would be measured – annually or by the minute. And in light of a largely industrialised, service-oriented economy, how localities, which are more industrial, rather than residential, would meet their energy demand with wholly localised resources. The scale of energy required meant that energy autonomy became more of an industrial question rather than an environmental one. Can the tiny size of the country really generate enough renewable energy to meet all energy demands, including mobility? Can energy autonomy address the local problems of energy consumption from commuting and rising energy demands due to growth in the population and the economy? These were questions that still required further clarification.

With regards to size, small-scale renewable energy installations on roofs and facades combined with the implementation of larger technologies have been shown by the Renewable Liechtenstein study to be sufficient to meet the Principality's energy demands. Reliance on offshore power was not considered by the study to be best for local and regional economic interest. Measurements, first taken annually, can monitor how self-sufficiency in electricity and heating can be achieved, and with time, sophisticated monitoring systems can be used to calculate supply and demand by the minute. With time, energy demands of industrial communities can be met through a networked approach across the entire Principality. All local governments would work as one energy supply network in assisting each other to gain local energy autonomy. As mobility was not within the scope of the Renewable Liechtenstein study, energy autonomy in mobility would have to be ascertained separately, since commuter traffic willl continue to have a great impact in the country. As for the rebound effect, the Renewable Liechtenstein study has already taken this factor into account.

The energy autonomy vision needs to be further discussed in relation to power structures, stakeholder responsibility, renewable energy technology development, changing economies and shifting lifestyles. Energy autonomy is essentially a long-term goal, and many decision-makers were wary in committing to goals that would last over 50 years. To think that far ahead is difficult given the short, usually 4- year political cycles, and given energy autonomy requires enduring partnerships. While the 100% target is essential to give a clear definitive outcome for the long-term, I argue that in the short-term, it may be best to frame energy autonomy as a communications strategy rather than as a performance tool because there would always be an uncertainty as to which measures will actually be implemented, how technologies will change and improve, and who will be in charge, over a considerable period of time.

Strengthening leadership

In Liechtenstein, none of the mayors were active proponents of the energy autonomy vision, in contrast to the vocal support for the Energy City framework. There was no elected figure who stood out as supporter or promoter of any alternative vision to that of the Energy City concept. This lack of interest in pursuing the vision may, at the highest municipal level, be attributed to experience, jurisdictional periods, low-level support from fellow peers, and party influence.

As shown, most of the mayors in Liechtenstein possessed backgrounds in manufacturing, economics or law. The more practical, cost-effective approach provided by the Energy City framework was therefore preferred because it pursued incremental improvements to achieve the points necessary to maintain the Energy City label, actions more achievable within the short mayoral term. A long-term vision of 50 or 70 years required to achieve energy autonomy did not fit with the 4-year political cycles and basic responsibilities in “servicing” rubbish, sewage and water.

Indeed, the Energy City label has not guaranteed continual mayoral leadership in energy matters. In 2013, the mayors of Vaduz and Mauren were the only people leading their municipal energy commissions, with another two mayors only involved during the Energy City auditing process. There remains a certain apathy amongst the mayors in Liechtenstein to do more than the norm. It was found that there was both an implicit and explicit understanding established through the Liechtenstein mayors conference that competition between them should be limited, if not avoided. With regards to accessing national subsidies for energy-related projects for example, these should be equal no matter the size or energy potential of that municipality.

Meanwhile, the political outlook has also slowed change. In Liechtenstein, mayors are affiliated with either one of the two major political parties: the FBP (Progressive Citizen’s Party) or VU (Patriotic Union). Despite both running on platforms that advocates energy efficiency and renewable energy via the free market, neither parties have articulated a clear position on the future of Liechtenstein’s energy supply. In fact, latest coalition statements have even left out provisions on renewable energy that had been clearly articulated in previous statements. At the municipal council level (Gemeinderat), maintaining interest or focus on energy matters has been a constant struggle. Those responsible for municipal energy have stated that energy was commonly and easily usurped as a priority by other issues over the course of several council meetings. As “lone figures”, energy matters had “to be fought for and reminded of constantly”, especially to prompt those in charge.

To pursue energy autonomy requires affirmative support, which means that mayors must, at least in the early initiating stages lead the local energy commissions. In the long-run, it is critical that the mayor or another prominent *community leader* is present to maintain commitment to the vision. At the same time, the nomination of future leaders that share the goal is key. Meanwhile, protocols are needed to ensure energy issues are given and maintain priority. The 'lone figures' need to be supported from the higher level. Leadership on energy autonomy must also be strengthened through a greater awareness of energy issues.

Building municipal knowledge and organisational capacity

Municipal knowledge of energy matters is relatively high in Liechtenstein but more so amongst those directly responsible for energy than the elected councillors. The analysis however showed that existing organizational capacities are sufficient to implement a variety of energy projects, since local energy commissions, and workgroups for special projects are in place and functioning. Ideological- or territorial-related barriers have prevented more active implementation however. The workshops showed that there was a fear of pursuing projects, which are traditionally the domain of the national government or the national utility. There was a fear to do more than was specifically prescribed by law, and a fear to go beyond the party line. The Energy City reports in fact revealed that the activities preferred were traditional measures that were generally routine, not highly innovative, and focused on promotional and discursive measures rather than concrete energy projects. A perceivable lack of confidence to implement more advanced projects has been a preventative, stagnating factor for local governments.

I argue that the training of the entire municipal administration can help develop the *confidence* needed to develop their own strategies, showcase their successes to other communities, and even reach out to neighbours to develop further energy projects through municipal coalitions. Since there will always be a lack of knowledge amongst those in change and those managing, the long-term envisioning process of energy autonomy requires a continual focus on improving municipal expertise on energy and environmental issues. Awareness raising activities within the administration would help counter uncertainty and general wariness amongst officials surrounding the notion of energy autonomy, replacing this with the awareness of the energy generation potentials and the economic benefits. The normalisation of the idea of energy autonomy through education, training and action is essential. The placement of a 100% target by one municipality can influence its neighbours and in the long run also compel the national government to also adopt the target.

Local energy commissions are mobilised and these should be maintained for the long-term. External energy consultants as the monitoring 'arm' should also be preserved. In Liechtenstein, energy consultants Lenum AG have been providing advice and development expertise on all municipal energy structure plans and cadastre plans, contracted by almost all of the municipalities to provide one dedicated officer for reporting to the Energy City program. One could argue that a unified approach was achieved by employing the same company throughout the country, a good basis for collective energy autonomy. As member of the national energy commission, its Director has also been able to reticulate local issues back to national level discussions. However, I argue that there is scope for local governments to also employ at least one in-house full-time staff member who is especially dedicated to local energy, separate to those responsible for local building, infrastructure, environment or economy, as traditionally the case. This figure can better coordinate actions of individual departments in pursuit of a common energy target.

Exploiting municipal autonomy

Liechtenstein municipalities possess a reasonable degree of political autonomy (as per the State Constitution [LR101, 1921]) to manage their own assets, local planning, water supply, sewage and waste disposal (GemG, 1996) and the right to pilot projects, revise structure plans, zoning plans and target-oriented implementation (BauG, 2008). In relation to energy they must still defer to the four national energy laws (EEG, 2008; EEV, 2008; EnAG, 2007; EnV, 2007). However, I argue that by pursuing their right to municipal autonomy to its full extent, municipalities can increase their chance of achieving local energy autonomy.

In recent years, municipalities have engaged in revising local building codes to guide renewable energy installations, manifested in separate appendices, extensions to Articles on roof forms, or completely new Articles in existing codes. Instructions are satisfactory but usually restrictive in nature and often vague. Sympathetic integration is to be achieved based on guidelines on size, angle, colour and fixings, albeit with no supporting illustrations. As for other renewable energy technologies, windpower is mentioned but only with regard to its positioning. Powers to revise existing codes so that they promote rather than hinder the installation of renewable energy technology have been used but not fully explored. Meanwhile, there are opportunities to implement landmark or lighthouse projects, and create frameworks for engagement with local businesses and industry to optimise their energy efficiency and integrate renewable energy, but these have similarly not been taken advantage of. The issue has not been the lack of political autonomy or even willingness but the lack of political confidence.

Based on their constitutional right to municipal autonomy, this should give them confidence to consider alternate visions to the Energy City framework. It is not about discarding the framework or denigrating its significance, but recognising that the Energy City framework is also a step towards energy autonomy because it actually provides the intermediate process and actions necessary to pursue the goal in the long-term, even if the target is not specifically articulated as a local or national policy. It would be critical to maintain the framework since it has been shown that the national energy strategy, which is based on the continuation of Energy City, can actually achieve energy autonomy in the long-term, as measures and targets were found to be consistent with those of the Renewable Liechtenstein study.

Recognising the limitations of the Energy City framework

Taking up Switzerland’s lead in implementing policies and initiating programs has been the traditional practice for the national government of Liechtenstein. The analysis in the chapter has shown that a new Act or Strategy introduced in Switzerland would nearly always result in a corresponding action by the country. At the local level, this has been reflected in the ready adoption of the Energy City framework administered by EnergieSchweiz, the official Swiss renewable energy and efficiency platform. This is reinforced by the national government’s energy strategy to maintain the pursuit of the Energy City label by all of its local governments. Based on in-depth reports to Energy City by local governments, some as long as 800 pages, much care has been given by Liechtenstein's municipalities to attain and maintain this label. The incrementalist approach of Energy City to local energy improvements has been fully internalised. The default method is to take many small actions to improve on previous measures and therefore achieve a better score in subsequent Energy City audits. For the local councils, *action-based-on-retrospection* has been a more cost-effective solution. However, one could argue that the Energy City process has also exhausted local government capacities, rendering any alternative strategies unnecessary.

I argue that the exclusive reliance on the Energy City framework has meant the inadvertent adoption of aspects that may not have been helpful for local government. For instance, its scoring system has compounded competition between municipalities since the scores discriminate in numerical terms the relative position of local councils to one another. It is unclear whether the percentage scores really provide a true representation of local government efforts since the geographic, economic, demographic and natural potentials of each local area are very different. One could argue that the only clear indicator would have been the percentage score on energy self-sufficiency. In any case, local governments have preferred to work independently, creating their own energy targets, developing their own building regulations with respects to renewable energy installations, and producing their own energy cadastres.

Cooperation with other municipalities and collaboration with organisations, companies or industry is still underdeveloped. This is compounded by the low points awarded for collaborative work, and although special projects outside of the municipality is encouraged, concrete energy supply projects, particularly with regional energy suppliers are not counted in the evaluation. Points for regional cooperation was even reduced in the latest revision of the Energy City's management tool. Meanwhile indicators for municipal-centred activities are many. Indeed, the idea of working with external parties to achieve local energy autonomy was considered costly according to the decision-makers in the workshop. Energy potentials modelling, feasibility analysis and community energy, forms, for example will require extended expertise and capacities beyond those currently in place for Energy City.

I argue however that by increasing awareness in energy autonomy (with scientific support), by garnering permission to envision energy autonomy as an extension of the Energy City framework (with national level support), and by exploiting national incentives for cross-municipal cooperation (again via the national level), can local governments become less wary of pursuing more collaborative innovative ventures.

Revising spatial planning and building codes

Spatial planning was an unknown quantity to most parties. A third of officials in the decision-makers workshop did not even respond when asked about the significance of spatial planning to achieve energy autonomy. Even the former director of the national spatial planning department, the office of which was disbanded in January 2013, could not provide solutions as to how energy requirements would be incorporated into spatial planning policy and regulation. There were few suggestions from other policymakers as to what further changes in existing local planning and building codes could take place, although when prompted, mandating PVs and solar thermal installations on buildings was generally supported.

With regards to building codes, taking stock of any deficiencies that discourages energy efficiency and renewable energy measures in the community has been difficult to achieve, as additions and supplements to existing rules have been the preferred method. Existing building codes are not illustrative and zoning plans do not make reference to energy in spatial terms, except for one zoning plan (Balzers). Although each municipality possesses an energy structure plan (Energierichtplan) and energy cadastre plan (Energiekatasterplan), these are confidential and for in-house administrative purpose only. This is despite agreement by officials in the workshop that energy information should aid the development of local energy goals and be made accessible to the general public. The confidential nature of the municipal energy plans is also reinforced in their omission from the local building codes. This close protection of plans reflects the determination of the municipalities to first, keep data secured from its neighbours in order to maintain their competitive edge, and second, to protect the identities of individual building owners, whose buildings have been mapped according to their energy performance and renewable energy technologies installed. Therefore, the energy plans have so far been primarily a means to gain further credits in Energy City audits rather than as effective vehicles to improve public knowledge and as a consequence, encourage active implementation by the community. Each municipality has access to nine local wind measurement reports commissioned by the Liechtenstein Solar Cooperative (LS), however in contrast these are all in the public domain.

There is tremendous potential to integrate energetic requirements into local spatial planning and building regulations. Efforts have begun to include guidelines for renewable energy technology installations in local building regulations by local governments. However there is still opportunity to clarify vague descriptions, or at least reduce restrictions in codes, which in turn should be linked to already developed energy cadastre and energy structure plans. The codes and plans should be made binding and most importantly publicly accessible. Meanwhile, improved municipal zoning plans can provide recommendations on the *preferred* development type, building type, orientation, density and form, according to energy performance. These plans would be useful for homeowners, potential builders and developers, since the energy demand and potential is graphically shown and clearly explained.

Because local planning and building practices differ very little between municipalities in Liechtenstein, which reflects the strong regional culture that works hard to maintain harmony and an overall regional building and landscape character, it is also important that the changes described above in revising individual codes and plans, be consistent in language and approach. This consistency can only be achieved through *national* building and spatial planning guidelines.

National stewardship in energy autonomy

The national government plays a decisive role in determining whether the municipalities would pursue energy autonomy as local policy. Their actions and policies have shown to be taken very seriously, and that for municipalities to pursue other activities than those officially sanctioned may be a difficult path to take. The municipalities have shown great reliance on cues by the national government, and a resignation that if measures are not specifically articulated, then it is not their business to undertake.

As described earlier, support at the national level for energy autonomy is present, but further clarification of terms and conditions is still required to make it national policy. The 2012 national energy strategy (Energiestrategie 2020) did consider the concept of energy autonomy as a valid and possible energy scenario, but it finally disregarded it as a “forceful” and “potentially costly” action for all. Acknowledgement is certainly the first step but it is interesting that the Strategy did not compare its 47 recommended measures and targets closely with those proposed by the Renewable Liechtenstein study, as this dissertation has shown that the country can actually reach energy autonomy based on these measures.

International obligations, party politics and national finances have impacted national attitudes towards an alternate energy vision and the degrees of implementation. These have inevitably filtered down to the local level. European Union legislation on energy that is incorporated into the national energy strategy for example is not directly enforced onto the localities. The preference for carbon reduction and carbon compensation before renewable energy as per the Kyoto Protocol has meant that renewable energy is subsumed within the Liechtenstein national Energy Efficiency Act (EEG, 2008) and not set with its own piece of legislation. Local governments similarly show first preference for energy efficiency and then for renewable energy. The detracting of positions on energy efficiency and renewable from political coalition statements has also created an environment of uncertainty as to what is actually supported into the future. Meanwhile, innovation by individuals, communities and local governments has been capped, first by subsidies that have been stringently regulated and second, by tariffs for fed-in electricity that have receded dramatically in the space of 5 years. Local motivation has furthermore been tempered by the need to maintain the regional status quo.

The latest 2012 Energy Strategy provides local governments with only four main responsibilities: public mobility, energy efficiency in water and waste systems, waste heat for localised heating and municipal energy cadastres for the formation of a nation-wide cadastre (Energy Commission, 2012). The analysis in this chapter shows that these are already municipal activities, and are therefore not extraordinary or future-driven. Other than the measures prescribed, the Strategy does not provide scope for the development of new, alternative ideas. It lacks deeper commitment to innovation or to challenge the municipalities to contribute their own ideas and to manage their own landmark projects. It failed to acknowledge the willingness by municipalities, as found in the decision-makers workshop, to collaborate, even on projects that are not traditionally a municipal activity. To achieve energy autonomy requires that the national government show trust in, and not underestimate, local government capabilities.

There is no reason for local governments not to approach the national government for assistance in the development of their local energy projects, or request participation in the development of national energy strategies. The national government should facilitate such engagement, either informally or by revising legislation on municipal autonomy to incorporate this aspect. A framework for municipal idea development, feedback and debate, is essential. This would avoid situations where national and non-government institutions would derail energy projects planned by the municipalities due to external expert feedback, without sufficiency opportunity given to local governments to respond. Changes in legislation may also be necessary to allow for municipal engagement with the national energy suppliers. The national government should consider the aspirations of their local governments and allow them to have a greater say in the future development of their local energy systems. There is also the opportunity for new national incentives for businesses and industries and incentives for intra-municipal cooperation to implement landmark projects.

In building and planning, national leadership is needed in creating guidelines for the spatial planning of communities that optimises energy efficiency and encourages renewable energy technology integration, which include illustrative design codes for renewable energy installations. First, the national structural plan (Landesrichtplan) should be reinstated (abandoned in mid 2013) and formalised to include energy requirements by delineating areas for energy production depending on technology, areas for future district heating networks, areas for potential building renovation, and areas distinguishing energy performance. These can then be reconciled with demands of existing historic conservation areas, nature protection zones, wildlife habitats and dangerous landscape zones. There is also potential to incorporate items that were omitted from the Renewable Liechtenstein study, such as spatial requirements with regards to mobility, energy storage and carbon sequestration. It can also account for the differences in local economies, distinguishing between communities that are industrial or residential. There is great opportunity to revise the plan to reflect a future vision that all stakeholders can pursue.

The focus on spatial planning of the 70s and 80s should also be revived and ideas reconsidered such as ideal settlement forms; building types, configuration and orientation; and public space and landscape design, but in the context of energy efficiency and renewable energy technology integration.

There is also potential for the plan to more importantly provide a common language for local government to use when adapting their own local codes and plans. An improved national structure plan also gives the chance to address the issue of *national and local identity*. Although the rise of the financial and service industries has erased any collective memory of past agricultural settlements that previously existed in Liechtenstein and therefore to recover the historic tradition of self-sufficiency in Liechtenstein may no longer be strictly relevant, there is still the possibility to adopt the vision of energy autonomy as a way to reinforce the independent, rural character of the region through energy and spatial strategies.

It should be noted that organisational changes at the national level will have a critical impact on the pursuit of energy autonomy. Recent changes in the national administration in 2012 have maintained incumbent areas responsible for energy such as the energy office and energy commission. However spatial planning has been made complicated and weakened in the splitting of the former Spatial Planning Office (Stabstelle für Landesplanung) into two separate departments, the national department and the local department. The local department is furthermore subsumed into the new Ministry of Construction and Infrastructure. This tenuous link between national and local planning, and moreover with the energy office and energy commission and its policies and activities, does not provide the best environment for the pursuit of energy autonomy in Liechtenstein as close coordination between those in charge in energy and those in spatial planning has been shown to be essential in achieving energy autonomy.

Restructuring to achieve energy autonomy would therefore be most likely required at the national level. Creating a separate energy development entity to pursue energy autonomy, particularly an entity to manage the implementation of larger scale projects such as hydropower on the Rhine, windpower and deep geothermal, may be essential in the long-term, however this requires further discussion between the two levels of government. In the decision-makers workshop, this aspect drew polarised views since separate entities to assist local government were considered to be already existing, such as the national Energy Office (Energiefachstelle) and the Liechtenstein Solar Cooperative (LS). However, it should be noted that these entities do not have executive control over the *rules* that their work is based upon. I argue that a more suitable option would be to focus on strengthening existing alliances.

Fortifying existing partnerships

The monthly conference of mayors discussed earlier has created an implicit understanding that competition is to be avoided in order to maintain regional status quo and harmony. One could argue that coalitions of municipalities could have helped overcome such ‘undesirable’ competition. However there was still some uncertainty as to the efficacy of cooperative work. In the decision-makers workshop, the idea of partnerships and alliances drew the most polarised views. For some officials, energy autonomy is a long-term idea that is difficult to prioritise because it is unrealistic within a prescribed political term. The partnerships required to achieve energy autonomy was seen to be difficult to maintain or to guarantee far into the future of 70 years or more. Although the Energy City framework ironically cites cooperation, be it with individuals, companies, or neighbouring municipalities, as one of its key organisational indicators, the eleven municipal Energy City reports have shown that collaborative effort has been very minimal. This is an attitudinal barrier, which exists in effectively decreasing the capacity for local governments in Liechtenstein to pursue energy autonomy.

Local governments can still however augment existing subsidies for energy retrofits of buildings that target businesses and industry, while actively promoting incentives to the rest of the community in the form of energy days, newsletters, lectures and seminars. They can encourage the entry of private enterprises in energy efficiency and renewable energy technology into the locality. They can also take better advantage of existing local organisations to carry out project construction or promotional work. For example, the National Association for Engineers and Architects (LIA) can help promote best industry practices in renewable energy technology, particularly in encouraging architectural practices that advocate energy autonomous concepts. It can also help the municipality to promote improved local building codes with illustrative guidelines for solar access and renewable energy technology integration. The Association can also assist in carrying out information exchange activities between the municipalities. Strengthened cooperation with the Liechtenstein Solar Cooperative (LS), the Wastewater Association of Liechtenstein Municipalities (AZW) and even the Liechtenstein Power Company (LKW) and Liechtenstein Gas Supply Company (LGV) can also greatly assist the municipalities to pursue the larger scale projects. This can be carried out as a cooperative rather than as a purely municipal venture. For example, municipalities can create new energy supply contracts with the LKW for the development of windpower and deep geothermal energy. Or they can construct local decentralised biogas CHP plants through new arrangements with the LGV to use local organic waste or biomass from local forestry waste.

Figure 123 shows that drastic organisational changes to local governments to pursue energy autonomy in Liechtenstein are essentially not necessary. However, national level departments, particularly those of national and local spatial planning must be given further executive importance, preferably through the establishment of a Spatial Planning Commission where it can reside, and be more connected to the Energy Commission and Energy Office. In addition, existing relationships between the municipalities and local and regional associations need to be strengthened and further supported by the national government. A national body to coordinate future implementation, particularly for managing future large-scale operations for deep geothermal energy, windpower and hydropower on the River Rhine will be necessary in the long-run.

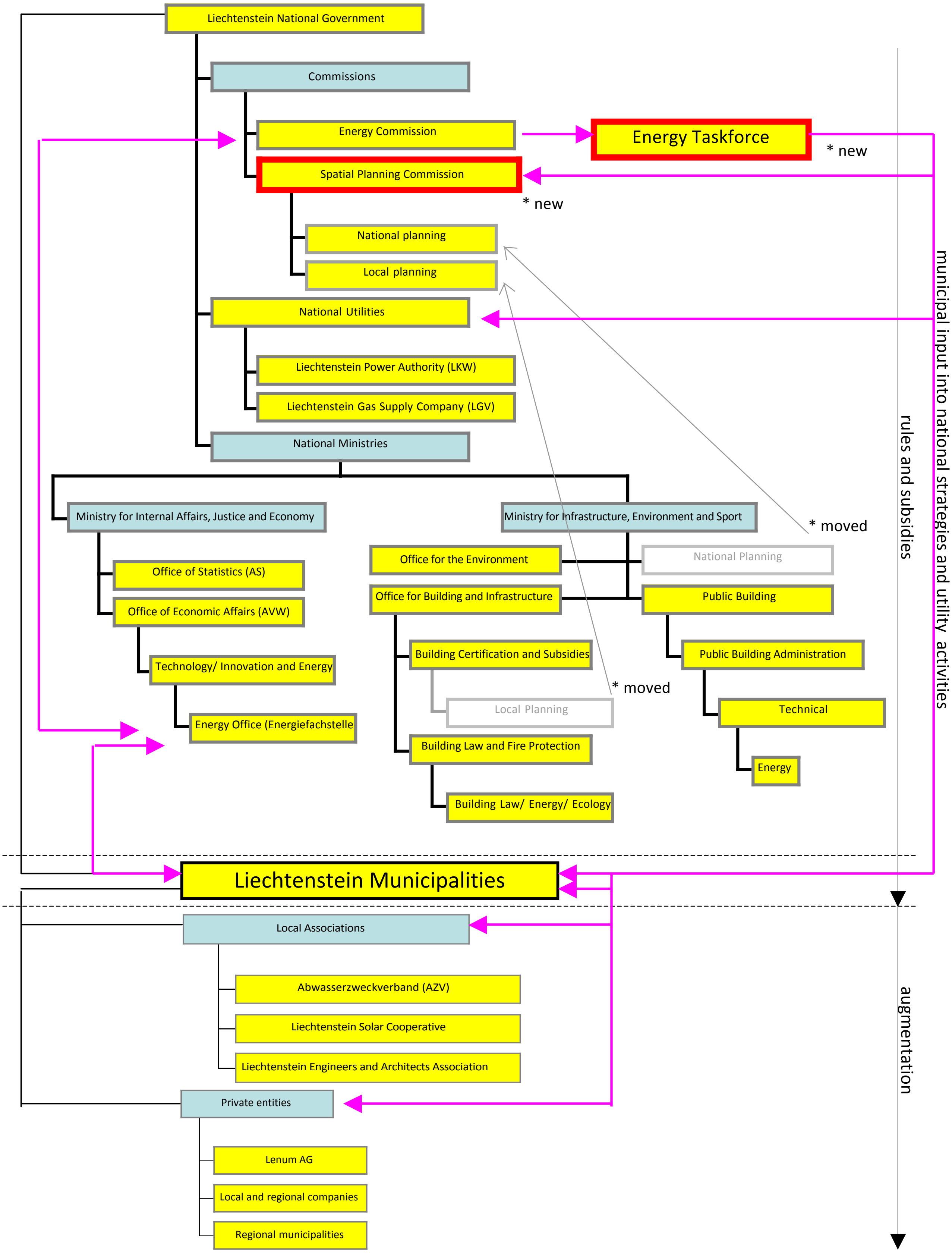


Fig. 123. Recommended changes to the organisational structures in Liechtenstein. Yellow boxes denote entities part of the energy transition. Pink arrows denote new or existing relationships.

Chapter 6. Governing urban development for local energy autonomy in Balzers, Liechtenstein

This chapter analyses the governance capacity of the municipality of Balzers in Liechtenstein to achieve energy autonomy via comparing the characteristics of its local governance in urban development against the six energy autonomy factors refined in Chapter 4. The recommendations presented in Chapter 5 for local governments in Liechtenstein were then tested to see whether they were a) relevant, and b) can be realistically applied by the municipality.

The six factors also serve as a guide with which to contextualise and frame the issues that underlie the challenges faced by the community in the pursuit of energy autonomy.

6.1 Context

In its Energy City audit of 2013, the municipality of Balzers in Liechtenstein received a score of 59%, five points above their previous score four years earlier. Based on existing trends, Balzers has the potential to achieve more ambitious energy targets provided that projects currently planned by the municipality are given the necessary political, economic and community support. To achieve energy autonomy as shown in previous chapters however requires a higher level of fulfilment according to the six energy autonomy factors, which were determined to be (in order of significance):

Factor 1: Local government leadership

Factor 2: Local government awareness of energy autonomy issues and capacities

Factor 3: Local government discretion

Factor 4: Local energy potentials models

Factor 5: Local government organisational change and augmentation

Factor 6: The role of the national government

In this chapter, the municipality of Balzers and its governance setting are analysed according to these six factors.

In Chapter 5, the recommendations outlined for the municipalities of Liechtenstein referred to:

- Reframing local energy concepts
- Revising existing or commissioning new local planning tools
- Improving own knowledge on energy matters and maintaining energy expertise
- Nurturing municipal or community leaders to drive energy autonomy
- Taking advantage of the right to municipal autonomy
- Recognising Energy City as a step towards energy autonomy
- Matching or augmenting national level incentives
- Setting up new or strengthening existing local partnerships
- Engaging with national government bodies responsible for energy

I also test here these recommendations on the municipality of Balzers.

Finally the Chapter addresses Research Question 5, as formulated in Chapter 1, which states:

'How can the recommendations for energy autonomy in Liechtenstein be implemented within the context of actual local government capabilities?'

6.2 Approach

This chapter is composed of three sections: analysis according to the energy autonomy factors, test of the Chapter 5 recommendations, and response to Research Question 5.

To examine the capacity of the municipality of Balzers, in Liechtenstein to achieve energy autonomy, the six factors on energy autonomy for achieving energy autonomy were employed to analyse local government practice. A municipal workshop, Energy City reports and interviews with energy consultants contracted to the municipalities, formed the primary basis of analysis; with further supporting information derived from historical documentary evidence including local reports, minutes, statistics, policy statements and press clippings.

Underlying motivation and issues that may influence the municipality to pursue energy autonomy was determined through a local government workshop and survey carried out with local policymakers and administrators as well as some invited leaders from the national government and national utility. Funded by the Energiewerkstadt research program under the European Fund for Regional Development (EFRE), the author of this dissertation was responsible for conceiving and evaluating the workshop process and corresponding survey. Members of the research team conducted the workshop event. Discussions were based on a local area model report 'Renewable Balzers', a strictly technical capacities model developed for the municipality, but based on the premise of the larger 'Renewable Liechtenstein' study and model. The aim of the workshop was to flesh out the governance and community organisational issues - consistent with the goals of this dissertation.

6.3 Background

6.3.1 Location

Balzers is the southernmost municipality in the Principality of Liechtenstein. It has a population of 4519 (in 2011), an area of 20 km^2, and lies 472 meters above sea level. The most prominent landmark is the castle hill with Gutenberg Castle located at its summit. The hill divides the town into two districts: Balzers and Mäls. The municipality's settlement and agricultural areas is located almost entirely on the valley floor. Steep rocky mountains and forests can be found to the northeast and south, whereby the land rises to the peak of Mittagspitz at a point nearly 1,900 metres above sea level. It is flanked by the River Rhine to its northwest and borders Switzerland on all sides except to the northeast (municipality of Triesen). Balzers also owns over 372 hectares of land and forests on the territory of the neighbouring Swiss canton of Graubünden. Part of that is leased to the Swiss Army.

Fig. 124. Location of Balzers (southwest) and its exclaves (east) in red. (http://en.wikipedia.org/wiki/Balzers).

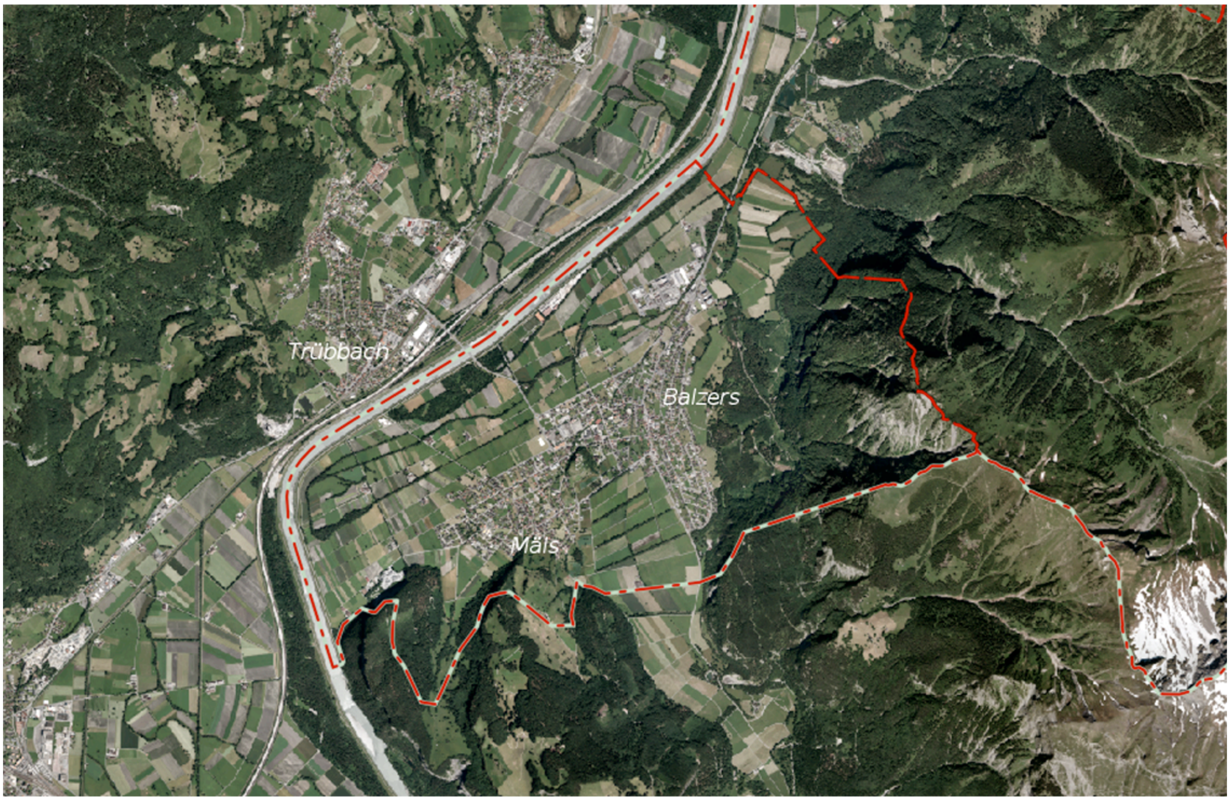


Fig. 125. Aerial of Balzers, 2012 (http://www.geodaten.llv.li).

6.3.2 Land use and settlement structure

Balzers is dominated by residential and agricultural areas, with some industrial zones close to the centre of town and on the peripheral areas bordering Triesen to the north. The municipality takes pride in its natural landscape, which provides a wide variety of special habitats for flora and fauna in the forests areas, wetlands, dry meadows and low hill-slopes. The warm south wind (Foehn) creates a mild climate, most suitable for local vineyards and cornfields. The hilltop castle is located right in the centre of town and provides an important geographical and historical focus. The commercial centre and the main public buildings are also found at the base of this hill. The principal church is built at a high level, providing an important symbolic heart to the community's cultural life.

Table 23. Distribution of urban space types in Balzers (Genske, Joedecke, Ruff, & Schwarze, 2013).

Use		Ha	%
Living	Pre-industrial old city	0.41	0
-	Small-scale village structures	4.97	0.3
-	Multiple family houses with commercial use	2.17	0.1
-	Multiple family houses without commercial use	8.87	0.5
-	One or two family houses	62.19	3.2
-	New building area: Single family houses	25.64	1.3
-	New building area: Multiple family houses	3.66	0.2
Working	Commercial and industry	18.56	1
-	Special use buildings	5.67	0.3
Open space	Green space	436.21	22.6
-	Agriculture	0.45	0
-	Forest	405.02	21
-	Water	5.3	0.3
-	Unproductive	894.31	46.3
-	Rest	57.63	3

Fig. 126. Balzers urban space types as per the Renewable Liechtenstein study (Genske et al., 2013).

6.3.3 History

Settlement has taken place in the area of Balzers since the Neolithic period. Historical documents have referred to the Rössen culture, which inhabited the area around 5000 BC (Vogt, 2007). When the Romans conquered the Alpine Rhine Valley and created the larger region of Raetia in 15BC, the area of Balzers became an important site for trading. Archaeological remains of Roman foundations, walls, tombs, Jewelry, coins and utensils have been found in the area.

Balzers was originally composed of two villages: Palazoles (Balzers) and Meili (Mäls). The name *Meili* is Celtic in origin and its significance is unclear, while *Palazoles* for Balzers comes from *palatium* and is interpreted as a manor, palatinate or royal residence (Vogt, 2007).

In the Middle Ages, Gutenberg Castle in Balzers became an important military stronghold of Austria and site of skirmishes between the Habsburgs and the Swiss Confederates. The Reformation was taking hold in the region as well as the peasants' revolt against the country's sovereignty.

In the 17th Century, the *Gemaindts* Book for Balzers-Mäls was created to record naturalizations, fees on depopulation and emigration, tree planting, community benefits, purchase agreements, border conflicts, leases and other aspects. In 1708, the 'community letter' was approved with a community regulatory system for land use, fences and transport arrangements. The town was by then an important gateway along the Lindau-Milan trade route. By 1808, Balzers-Mäls was declared a political community with village rules on agricultural practices and freight transport. In 1811, the municipality of Balzers resisted the privatization of community land and was able to maintain the majority of the land as common property (some until this day) (Vogt, 2007).

With the expansion of road and rail in the Swiss territory from 1850, freight was no longer a source of income, forcing seasonal work in neighbouring countries (Vogt, 2007). Local men travelled to other European Alpine countries for work in construction or crafts. The women and children had to remain home and become self-sufficient on their small farms. Local work only flourished after the turn of the century when the industrial and commercial enterprises arrived.

Until the first bridge over the Rhine was built in 1871, the Rhine River was crossed by ferry. In 1894/5 water pipes were built to contain the typhoid epidemic, and in 1897, the telephone network was connected.

The Customs Treaty of Liechtenstein with Switzerland in 1924 brought change for Balzers in terms of growth and diversity. The borders with Switzerland were open and smuggling over the Rhine ended (Vogt, 2007). Despite unemployment, loss of assets and limited income opportunity in the 1930s, the area experienced rapid economic development after 1945. Agriculture, home-based businesses, construction, trade, seasonal work abroad was gradually replaced with industry, administration or service sector employment. From the 1950s, the settlements of Balzers expanded rapidly, necessitating the upgrade of local infrastructure. In the 1960s, several areas were rezoned for housing, commercial and industrial activity. A number of public buildings were also progressively built (Vogt, 2007).

The explosive growth since the 1970s brought opportunities but also some loss of identity with respect to cultural heritage. The disappearance of old structures of agriculture and crafts however has not stopped the revival of village culture, association building, and pride in the rural way of life and character. According to local mayor and historian Arthur Brunhart, the "rural world is undergoing a metamorphosis that may open up opportunities for education and social advancement" (Vogt, 2007).

6.3.4 Current energy supply and demand

The municipality of Balzers has historically imported its electricity, and sourced fossil fuels in the form of oil and gas for heating, via the national energy suppliers, the LKW and the LGV. In 2012, 75% the final energy demand was met by imported fossil fuels.

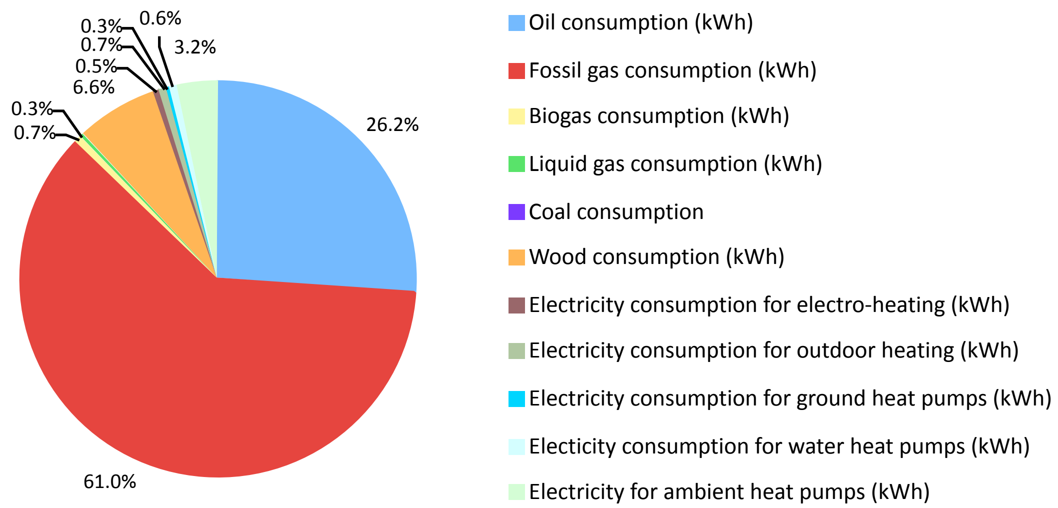


Fig. 127. Percentage of primary energy source consumption in Balzers in 2012 (Based on data from Lenum, 2013).

Although greenhouse gas emissions has dropped from 9.23 to 7.67 tonne of CO_2 equivalent per capita in recent years (between 2009 and 2012), this was most likely due to the increased share of nuclear energy in the energy mix (Lenum, 2013). Within this period, the primary energy consumption had actually increased from 6996 to 7335 watts per capita.

In 2012, heating accounted for 40 % of the total final energy consumption. The residential sector was the highest heating consumer. Despite this, the absolute heat consumption for the household sector has decreased by 3% since 2009. Within the three-year period, the share of renewable heat rose from 9% to 20%, a direct result of the increase use of wood energy, solar thermal, heat pump, and biogas for heating energy. The use of heating oil in the municipality has therefore declined.

Meanwhile, electricity accounted for a quarter of the total final energy consumption in Balzers in 2012, an increase of 7.4% since 2009. This is however mainly due to the purchase of green power. By switching to green electricity (LiStrom Natur or LiStrom Natur Plus) in the household sector, the renewable electricity share rose since 2009 from 18% to 24%. The municipality administration also purchases electricity made up of 86% LiStrom Natur, and 14% LiStrom Natur Plus. LiStrom Natur consists of 95% electricity from hydroelectric power, 2.5% photovoltaic energy, and 2.5% LiStrom Natur Plus. LiStrom Natur Plus consists of 65% power from drinking water turbines, 5% photovoltaic energy and 30% energy from sewage gas. In Balzers, the production of photovoltaic electricity, which is sold to the LKW, has grown by a factor of 9 compared to 2009. The production of electricity from gas-fired power-generation has declined slightly. The industry sector remains the highest consumer of electricity and water.

Natural gas driven co-generation plants of Bruel and Gnetsch in Balzers provide an average of 700MWh of heat and about 300MWh of electricity production a year, connections to which can be potentially extended. Natural gas is derived from sewage gas, and is converted to certified green electricity through digesters, regulated by the Liechtenstein Wastewater Association. All black waste including bio-waste is exported to the incineration plant KVA Buchs in Switzerland for conversion to heat and electricity. This heat is imported back to Liechtenstein to serve two major industrial plants in Schaan.

In 2012, renewable energy sources (RES) only constituted around 19.7% of heating and 24% of electricity, even though the share of renewable energy (final energy) has increased from 8% to 14% since 2009.

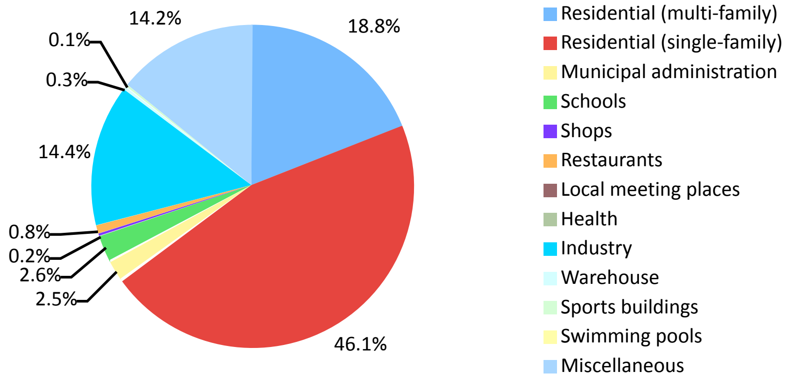


Fig. 128. Percentage of total heating consumption according to building use in 2012 (Based on data from Lenum, 2013).

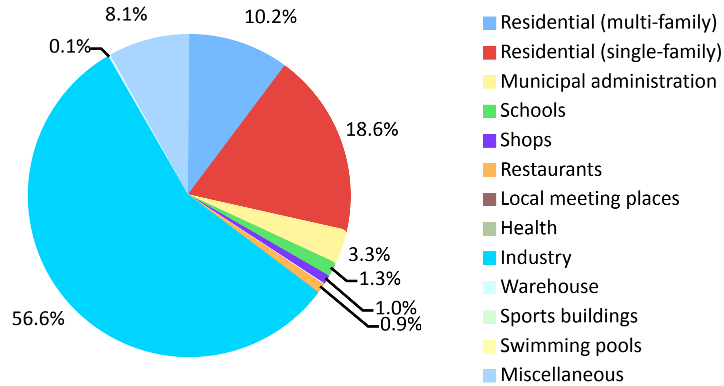


Fig. 129. Percentage of total electricity consumption according to building use in 2012 (Based on data from Lenum, 2013).

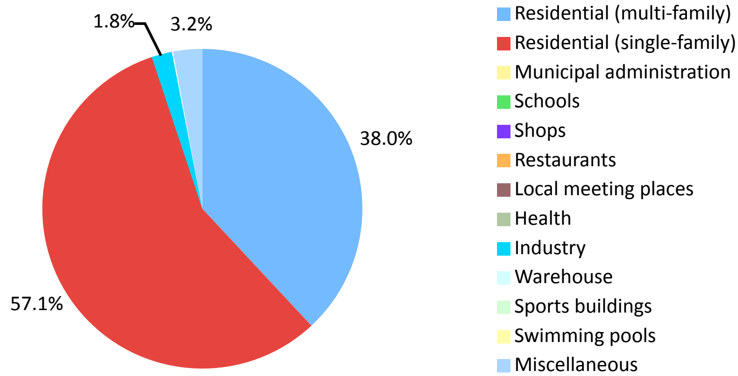


Fig. 130. Percentage of total solar thermal generation according to building use in 2012 (Based on data from Lenum, 2013).

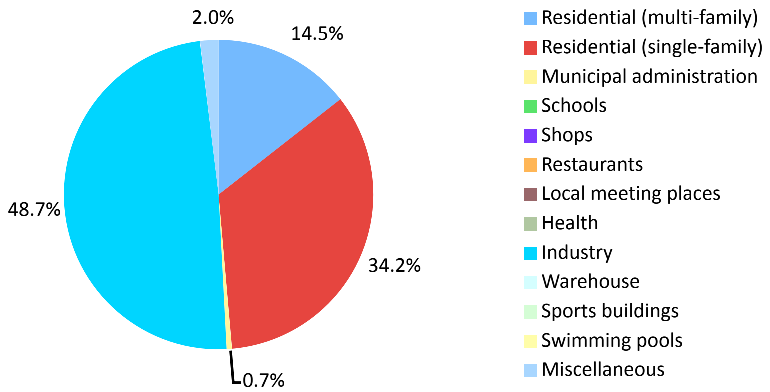


Fig. 131. Percentage of total PV electricity generation according to building use in 2012 (Based on data from Lenum, 2013).

Fuels for transportation has remained reliant on petrol and diesel. Not much has been done on renewable fuels for mobility in Balzers. Indeed, measuring the energy consumption in mobility has been very difficult due to the inadequacies in the existing database. In 2012, the renewable mobility share was well below one percent. Only one electric car using green electricity was in use. Since 2009, the total energy consumption in mobility has increased due to a rise in the number of passenger cars per capita from 0.66 to 0.69 (that is, 166 vehicles more). Although, the number of large-engine vehicles (over 3000 cc) has lowered by 8%, the number of passenger cars with engine capacity to 2999 cc, has consistently increased (Lenum, 2013).

6.3.5 Future energy supply and demand

Population growth in Balzers has been steady during the past 40 years (See below figure). A moderate population and economic growth is forecasted for the municipality by 2050. Through energy efficiency and renewable energy measures, the national energy strategy ES2020 (Energy Commission, 2012) aims to stabilise the future energy consumption as a consequence of the predicted growth.

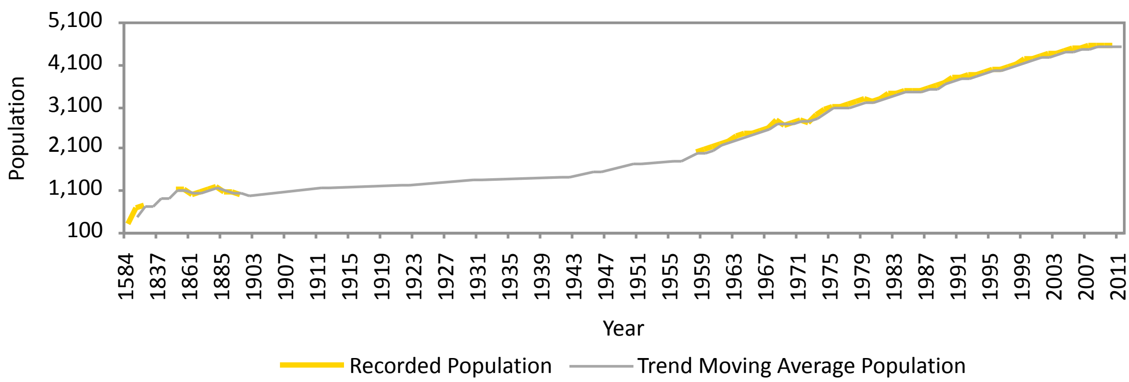


Fig. 132. Population growth between 1584 and 2011 in Balzers (Based on data by FL, 2012b).

The municipality has commissioned an energy strategy that points the way towards Balzers becoming a 2000-Watt society. The specific objectives of the strategy are outlined below.

Municipality-wide energy consumption objectives correspond to the objectives of EnergieSchweiz (Translated from Energy City report, Balzers Municipality, 2009, p. 13-14):

- Objective 1: Raise the proportion of Minergie and Minergie-P buildings within the next 10 years as of 2009 from (Minergie 128 m^2/1000 residents to Minergie 5000 m^2/ 1000 residents) and (Minergie-P: 0 m^2/ 1000 residents to Minergie-P 500 m^2/ 1000 residents).
- Objective 2: Raise the share of renewable energies in heat in the next 10 years by 15% as of 2009.
- Objective 3: Maintain electricity consumption for all sectors (MWh/a) at 2009 levels.
- Objective 4: Stabilise greenhouse gas emissions at 2009 levels.
- Objective 5: Maintain support of public transportation, foot and bicycle traffic.
- Objective 6: Maintain the unabsorbed excess amounts of water (wells, construction water, fire, leaks, etc.) at 2008 levels.
- Objective 7: Maintain water consumption at 2008 levels.

Municipality administration energy consumption objectives are as follows (Translated from Energy City report, Balzers Municipality, 2009, p. 14):

- Objective 1: New buildings and renovations are performed to Minergie-P standard.
- Objective 2: Raise the share of renewable energies in heating in the next 10 years (38%) to > 50% as of 2008.
- Objective 3: Reduce the requirement for electricity (kWh/m^2) of municipal-owned property over the next 10 years from 50 kWh/m^2 to <40 kWh/m^2 as of 2007.
- Objective 4: Increase the renewable energy share of electricity purchases in the next 10 years from 4.5 % to 25 % (including public lighting) as of 2009.
- Objective 5: Decrease water consumption (m^3/m^2) in the next 10 years from 1.03 m^3/m^2 to <0.8 m^3/m^2 as of 2009.
- Objective 6: Tenders for construction and supply contracts are made on the basis of ECO Devis or with the help of a professional office.

In most areas, the municipal-wide and administration’s energy objectives proposed in 2009 have already been reached in 2012. In other areas, Balzers has developed a new timetable with amended objectives for 2020.

To reach the energy objectives in heating and electricity, Balzers’ latest 2000-Watt energy strategy outlines the potential activities and amended targets:

Table 24. Balzers' energy concept measures and targets (Lenum, 2013).

	Measure	**Target**
Heating	Raising awareness of the population regarding heating and hot water consumption. Cooperation with industry with respect to thermal efficiency and substitution of fossil fuels.	Maintain a renovation rate of 2% per year.
	PV in combination with a solar heat pump is most cost-effective solution.	Increase by 150 MWh/a
	Substitution of oil heaters/gas heating with wood heating	Increase by 240 MWh/a through building remediation measures.
	Heat pumps	Substitution of oil heaters by heat pumps through remediations of

	Measure	Target
		building envelope, by 140 MWh/a
	District heating from forestry wood	Target at least 60% of the potential use by 2020 (14500 MWh/a) by industry.
Electricity	Increase public awareness on the best technologies and improved user behaviour, through Environment and Energy Days. Collaborative work with industries, businesses, the local Energy Commission and the local Economic Commission.	Reduce energy consumption by 9 MWh per workplace
	More PV support programs, events, advice on individual properties	Achieve 210 MWh/a (about 1260 m^2) growth rate.
	Contact with Liechtenstein Solar Cooperative	Achieve potentials as per wind measurements.
	Hydropower	Potential of a 30 MWh Rhine hydropower power

The 2000-Watt strategy for Balzers indicates that waste heat from industry, wastewater heat and geothermal heat provide no realistic heating energy potential for the municipality. Similarly, electricity from biogas derived from green and organic waste, windpower, and geothermal energy is also not considered realistic or sufficient due to the small size of the local government area.

However, it is estimated that the potential for expansion of renewable energies in the municipality Balzers totals 63 GWh, consisting of: wind turbines at 3 sites (16 GWh), photovoltaic systems on roofs (15 GWh), heat pumps (8 GWh), solar thermal (11 GWh) and biomass (13 GWh) (Lenum, 2013). The potential from waste heat recovery is not known. By 2020, energy consultants to Balzers, Lenum AG predict that 40% of the electricity and 30% of heating will come from renewable sources, assuming current trends (Lenum, 2013). Biomass plants and district heating networks are being successfully implemented, however, other areas of potential such as windpower, hydropower, solar arrays on all roofs, and ground-source heat pumps will require greater effort in strategic leadership.

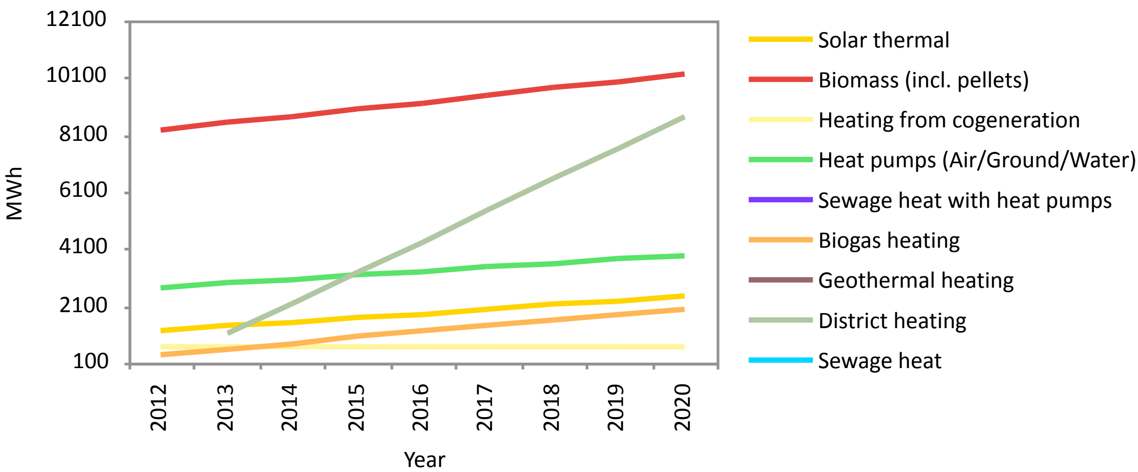


Fig. 133. Renewable heating targets for Balzers (Lenum, 2013).

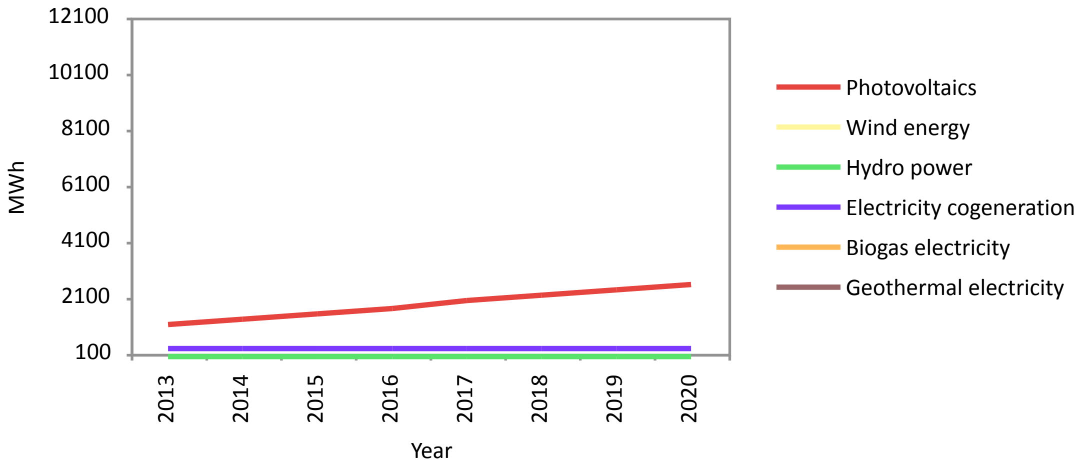


Fig. 134. Renewable electricity targets for Balzers (Lenum, 2013).

6.4 Analysis based on the six energy autonomy factors

6.4.1 Factor 1: Local government leadership

Even though energy autonomy has never been an institutional goal for Balzers, the pursuit of environmental awareness has been strong in the municipality since the 1990s. In 1997, a public strategy was devised incorporating the feedback of the entire community to create “Citizens Together for Balzers” (Metanand för Balzers), which specifically advocated the use of alternative energy in the municipality. It is a community mindset that harks back to the rules and codes governing common land in Balzers during the Middle Ages as described earlier. The importance of self-sufficiency on local farms particularly during times of war, poor economies and drought instilled a sense that communal effort was essential to its survival. Although it was found in Chapter 5 that the shift to a more industrialised economy in Liechtenstein has meant that village life that was dependent on local agriculture, forestry and trade between neighbouring communities was no longer relevant, there is still a strong movement within the municipality of Balzers and its community to maintain the agrarian-village identity and independence. This is evident through statements in the 1997 strategy and the latest 2012 mission statement for the municipality.

This local sense of cultural self-sufficiency provides a good ideological basis for pursuing energy autonomy.

Despite its pride in *political* autonomy, *energy* autonomy has not figured in any municipal discussion. There has been no impetus or signals to formally pursue alternate goals to Energy City’s 2000-Watt targets. There is no mention in council minutes, press releases, newspaper reports or other material concerning the idea of energy autonomy for Balzers. Only political, or more specifically *municipal* autonomy is mentioned regularly and fiercely defended. Most publicised also have been the qualified and quantified energy and climate policy objectives (including statements regarding mobility), which have been in place since 2009. However, Balzer’s municipal targets show great scope for advancement towards energy autonomy. The following table shows that the targets have actually been more ambitious than those of the national energy strategy ES2020.

Table 25. Energy targets for the municipality of Balzers until 2100, compared to the national energy strategy target [*] and Renewable Liechtenstein target [**] (Based on Lenum, 2013 and Energy Commission, 2012).

	2009	**2012**	**2020**	**2035**	**2050**	**2100**
2000-Watt calculation (W/inhabitant)	7000	7300	6500 6200*	5500 5000*	4600 3800*	2000
Greenhouse gas CO_2 eq. (t/inhabitant)	9.23	7.7	6.5 5.6*	5.2 3.7*	4 1.7*	1 1*
Renewable energy share (%)	8	14	24 20*	38 **100 for electricity	50 **100 for heating	75

Balzers' climate and energy action plan outlines the mid- and long-term goals and strategies for Balzers and includes a reduction scale (primary energy demand of renewable and non-renewable energy, and CO_2 emissions) that aims to increase efficiency and emission reduction, makes full use of local renewable energy production, and preserves the natural environment and agricultural activities. It also aims to conserve water, promote sustainable modes of transportation, and support the procurement of regional goods and services. The achievement of these objectives is subject to periodic internal review and communicated externally through annual reports.

Leadership is demonstrated in the articulation of these targets, and in the reaffirmation of climate and energy policy commitment by maintaining memberships in the Energy City (Energiestadt) and the Covenant of Mayors programs.

Leadership in more ambitious visions such as energy autonomy is formerly absent, despite the tacit support or sympathy for it by the mayor and local councillors as shown in the Balzers local government workshop, which was held at the end of 2013 with local decision-makers and energy experts on the theme of energy autonomy for Balzers. One could interpret that when the mayor of Balzers, Arthur Brunhart agreed to participate in this workshop organised by the University of Liechtenstein, a significant step forward was made in terms of leadership because although the free offer for a workshop was extended to all eleven municipalities, only the mayor of Balzers had accepted. In their replies to the invitation, the other ten mayors indicated that an energy autonomy workshop was not considered necessary or appropriate for them. The acceptance on the part of Balzers' mayor therefore demonstrates a readiness, willingness and curiosity to consider new ideas and to try new methods. Another local councillor, who was police chief and head of the municipality's energy department similarly showed great leadership in mobilising the relevant parties from the council when organising the logistics for the workshop. One could argue that these two figures are not dissimilar to the pairs that have led the energy autonomy communities discussed in Chapter 4.

There is much promise in the mayor to assume greater leadership in formalising the energy autonomy vision. In Chapter 4, it was revealed that the mayors of the energy autonomous communities all had backgrounds in the sciences or the humanities, besides experience in local politics. Mayor Arthur Brunhart has a background in history and anthropology, a humanities base, which is in contrast to the predominant experience of the rest of the country's mayors, which lay in economics, finance, law or manufacturing. From 2005 to 2013, Brunhart was a politician and member of the national parliament, representing the Patriotic Union Party (VU). He chaired the EEA Commission from 2005 to 2008. From 2009, he was head of the delegation of the Parliamentary Commission of Lake Constance and was Chairman of the Foreign Affairs Commission. In recent years, he has worked at the Liechtenstein National Museum and held the position of Deputy Director of Languages. In the municipal elections of 2011, he was elected mayor in his hometown of Balzers.

Apart from the mayor, the current director for Balzers municipal energy planning is also a member of the Patriotic Union Party (VU) and is responsible for policing and civil protection in the municipality. Formerly a local mason and builder responsible for public amenities, there is great potential for this individual to act as the necessary counterpart to the mayor in motivating the rest of the council to pursue energy autonomy. As a charismatic motivator, not unlike Soren Hermansen in Samsø, this particular individual possesses (the necessary) strong local connections and experience that could potentially mobilise the entire community. It is important to note that he also implicit supports energy autonomy, as indicated in the local government workshop, but only provided that it benefits the entire community.

The experience, qualities and identity of these two figures provide good leadership conditions for setting down local targets and mobilising the relevant actors and actions for pursuing local energy autonomy.

6.4.2 Factor 2: Local government awareness of energy autonomy issues and capacities

In November 2013, a local government workshop on energy autonomy was conducted to explore the level of municipal awareness of energy autonomy issues and capacities. The event finally revealed that the municipal actors in Balzers were generally aware of the vision but queried whether the vision would make economic or geographic sense. This section describes in detail their perceptions and issues with regards to energy autonomy.

Local Government Workshop 'Energiewerkstatt Balzers', November 2013

The mayor of Balzers, officials from the municipality of Balzers related to energy, Balzers Citizens Cooperative (Bürgergenossenschaft), energy consultant Lenum AG, Liechtenstein Solar Cooperative (Solargenossenschaft), the EKP Group, the Technical University of Nordhausen, and the University of Liechtenstein came together to discuss the state of energy supply and project implementation in Balzers through a single municipal workshop. Twelve out of the eighteen people who attended were directly related to the development and maintenance of the municipality's 2000-Watt energy program.

The workshop began with four presentations: the Renewable Liechtenstein model results by the University of Liechtenstein; the Balzers energy strategy - policies, plans and projects by Lenum AG; the wind power and solar energy potentials study for Balzers by the Liechtenstein Solar Cooperative; and the capacity model for energy self-sufficiency for Balzers by the EKP Group and the Technical University of Nordhausen.

The presentations were followed by a group discussion, structured around the six themes of the Energy City framework. Each theme was represented on an A1 panel that was pinned up onto the wall to prompt discussion through free-hand note taking. Because the themes were already familiar to most of the workshop participants, attention was immediately directed and focused. On reflection, each theme encompassed such a wide variety of measures, such as 'Supply', which included waste, water and energy, to clearly categorise and identify priorities, and therefore may not have provided a sufficient comparison of measures.

The participants were asked to first differentiate the themes using coloured stickers according to the areas of greatest strength (green dot), areas currently underway (yellow dot) and areas for improvement (red dot). As a group, it was agreed that two extra panels were necessary, in addition to the six usual themes, for ideas and lighthouse projects (Leuchtturmprojekt). After the themes were categorised, each theme was discussed in more detail with regards to specific projects, each of which were similarly differentiated according to their strengths and weaknesses. This was followed by identifying the ideas and lighthouse projects, and then to identify the project, which each participant as representative of their organisation felt they had most affinity to, or they felt they could do the most. The workshop ended with a brief discussion on the potential for expansion of renewable energies in the community with regard to energy autonomy. This aspect was also queried in a written follow-up survey given after the workshop.

The presentations served to remind and re-educate, while the discussion served to highlight the roles of each municipal and community actor, and to pinpoint the shared interests in order to find evidence for the need for new and stronger partnerships. To operationalise energy autonomy requires the implementation of a diverse range of energy technologies, demands of which entail a variety of ownership or organisational styles. The discussion also gathered views of those in charge of the energy domain in Balzers, therefore serving to increase interactivity between key members, and encourage the ownership of ideas that have yet to or have failed to be implemented.

Findings from the municipal workshop

Presentations

Based on the comments from the workshop and survey, the presentations by the different experts were found to be long but useful in not only *celebrating* the municipality's achievements but also in *highlighting* the fact that the municipality could do more. There was a small element of information-fatigue as participants were faced with a large amount of information during the presentations. Therefore queries following the four expert presentations were very few. Questions only referred to whether the studies considered future population increases, growth in mobility, and raising the use of heat from biomass plants. For Balzers, these were the most pressing issues at the time.

Group discussion

Of the six Energy City themes, 'Public buildings and infrastructure' was the area the municipality was most proud of. 'Supply' (in relation to energy, water and waste – as per the Energy City classification) was the area that was currently in progress, and which the municipality "had good ideas about". 'Mobility' and 'Communication and cooperation' were the areas that needed the greatest improvement. Interestingly, 'Strategy or space' and 'Internal organisation' did not receive any definitive response or feedback. In other words, participants were neither proud of, had good ideas, or even considered as areas for improvement – as the two themes garnered the most apathetic responses.

Despite the initial indifference, 'Strategy and Space' did garner some comments, but not directly related to energy, but rather to planning in the traditional sense, whereby Energy City as a planning framework - organisational, not spatial - was in place and was working strong. In this light, planning for the creation of incentives for industry for example was missing. Admittedly, there was also potential to improve spatial planning, but only in relation to building laws.

'Public buildings and infrastructure' was considered the strongest of all of the six themes, largely due to the municipality's pride in its green energy procurement framework, thereby enabling it to declare that nuclear power and fossil fuels were not part of its energy mix. Public asset management was seen as a strength, but according to one attendee, this was partially true since it could only be correct if the energy consumption patterns of users in those buildings were not considered. It was argued that in reality, the municipality has not cared much about the behaviour of people in public buildings. There has been no program for influencing users behaviour in schools, halls or other municipal facilities. A possible solution suggested would have been to create a user concept for municipal buildings, particularly for those that are under-utilised so that their use can be conceptualised in a way that optimises energy efficiency. This suggestion was generally supported.

'Supply of energy, waste and water' was also considered a successful area of intervention. Workshop participants highlighted that the municipality to date possessed a good, reliable energy infrastructure. But according to one official from the local economic commission, supplies are only 'safe' if there are no wars, or cuts in supplies, giving the example of what would happen if there was a nuclear war or if Russian gas supplies were cut. In other words, what was seen to be strong for one person was seen to be a weakness by another who was more aware of the risks of conventional, centralised supply systems and the advantages of a local energy base. In Balzers, it was noted that a new district heating (wood fire) project was at risk because there was a uncertainty as to whether it would be approved. In this case, heating supply was not 'safe' since the municipal officials themselves were unsure of the fate of the project. This uncertainty factor can also be applied to the situation with community plans for local wind turbines, which has yet to gain approval from the national government. For the workshop participants, there has been a dichotomy between, and a shift in interpretations of infrastructure that was 'strong' against one that was 'risky'. In the end, the workshop participants agreed that at the very least, the municipal and community 'hardware' was sufficient to supply itself with "better energy".

'Mobility' was marked as a weak area. The only positives noted under this theme related to the public transport system and the project for electric plug-in points for electric bikes. Although they were both underway, these have largely been the domains of the national government. Similarly, national projects to connect bike paths between municipalities and across to Switzerland, and preserve the right-of-a-ways for track-based transport are also having an impact on Balzers. Despite the national initiatives, these have not prompted the municipality to carry out its own mobility measures besides the creation of bike and pedestrian routes and the design of public spaces. It was finally admitted that the municipal area itself has not been entirely bike-friendly on account of inadequate sidewalks and bike paths, and no mobility management by the municipal government.

'Internal organisation' was not considered strong. Indeed, the theme elicited very little reaction from workshop participants, with most agreeing that it was "just there". The municipal energy director maintained that organization for energy matters was already in place. However when it was queried as to whether there was a need for strategic change to push forward projects even further, there was a general undercurrent of agreement. The participants supported the proposal to create a local 'Energy Table' (Energietisch), a group that would incorporate not just those directly connected to the local energy commission but also representatives from other municipal departments and community groups. But whether further talks are necessary is questionable according to one participant, who asserted that the new focus should really be on the implementation of real measures.

Giving the example of the catalogue of measures in the national government's Energy Strategy (ES2020), it was argued that there is potential for local governments to finally understand what these would mean at the local level and to act accordingly. It would be useful for the municipalities to use the catalogue to help *prioritise* measures, especially since no implementation task force exists at the national level responsible for operationalising projects. The ES2020 has yet to influence local government discussion. On the other hand, it was also recommended that local governments should just focus on their own energy strategies since their targets are more ambitious and due to their small size, community mobilisation will be quicker. Only then, can they collectively contribute towards achieving the national targets, or finally pursue energy autonomy. The response to this independence proposal was generally positive but there was a sense that to pursue goals unrelated to the national or Energy City targets was still a rarefied idea. Municipalities in Liechtenstein may not be confident enough to pursue this for fear of 'stepping out of line'.

'Communication and cooperation' was another area needing further improvement. The municipality highlighted its biannual Energy and Environment Day as one successful municipal event. There were admittedly good in-house programs for industry but the participants argued that what was really needed was a program for small and medium-sized enterprises (SMEs). Several recommended a central contact point for advice such as local advisory service for SMEs as well as for the training of architects. They questioned why the municipality should not have its own energy office, rather than having to rely completely on the national energy office (Energiefachstelle) for technical, financial and promotional advice. The municipal citizen's cooperative society (Bürgergenossenschaft), whose charter includes the management of common Alpine land - and therefore of potential sites, also agreed that there should be an 'information clearinghouse' for architects. But when asked who exactly would be responsible for these measures, workshop participants could not provide an answer, though admitted that it should be at the local level. When the community society members were asked whether they could play a role, they replied that they had no resources for such tasks. A representative from the Solar Cooperative suggested cooperating with the Liechtenstein Association for Engineers and Architects (LIA).

Other participants suggested that the local government also improve its economic program to promote clean technology by encouraging the introduction of industries of this kind into Balzers. This could create a type of cluster of excellence that encourages existing industries in the same area to have better buildings and therefore express their own environmental aspirations as a company. (It is important to note that despite the agreement by actors in the workshop for this specific proposal, Energy City reports reveal that the promotion of “green industries” has not been a priority in Balzers because of the lack of land, and the perceived limited potential for economic growth).

In addition to the creation of an energy user concept in public buildings, municipal officials conceded that communication would also need to be intensified in order to shift old patterns of behaviour even in the private domains of working and living. How this communication would be intensified was not explicitly articulated.

Table 26. Achievements and areas for improvement for Balzers.

Field of action (Energy City theme)	**Achievements**	**Potential**
Strategy / Space	Decision to use no nuclear power in municipal buildings. Best planning in the context of planning guidance, e.g. strengthening the internal development and traffic calming measures. Successful re-audit of the Energy City label in 2013.	Creating incentives for industry to promote ‘green’ businesses.
Municipal buildings and infrastructure	No use of nuclear power. Adequate supply with renewable energy.	Influencing and improving user behaviour. Developing strategies to optimise use.
Supply	Presence of a well-developed infrastructure. Commissioning of a wood heating plant (in preparation). Wind power potential studies.	Improving security of supply / quality by reducing dependence on energy imports Reducing energy consumption and expanding renewable energies on site.
Mobility	Good public transportation and financial incentives for potential users (commuter tickets). Providing power for electric mobility (free use of a bicycle-e-filling station at the town hall). Improving the continuity of bicycle paths within Liechtenstein and connections to Switzerland (currently being reviewed by the country and promoted).	Improving bicycle suitability, creating bike paths and points of contact. Discussing with the population the option of a new rail line. Improving mobility management and developing parking concept. Changing the municipal vehicle fleet to electric mobility in the long-term.
Internal organisation	Local energy commission installed as part of the implementation of the Energy City measures involving the Building administration, the Energy Commission, the Environmental Commission, and the Economic Commission. Continuous updating and improvement of the municipal energy concept.	Improving informal exchange within the administration by installing a regularly scheduled ‘Energy Table’ (Energietisch).

Field of action (Energy City theme)	Achievements	Potential
Communication/ cooperation	Organization of energy and environmental days to improve knowledge transfer and exchange of experience with industry. Training of building professionals, through for example Ecoplan, with scope to expand the program or introduce new ones.	Improving advisory services to clients (individuals, SMEs, industry) on energy efficiency, integration of renewable energy, financing. Increasing awareness and participation of citizens in the implementation of the Energy City concept.
Industry	Programs for industry available.	Promoting SME advisory programs.

Table 27. Ideas and lighthouse projects suggested by workshop participants to increase energy efficiency and to expand renewable energy in the community.

Proposed ideas	Lighthouses or landmark projects (Leuchttürme)
Developing a community-wide car-sharing program. Examining the potential for waste heat recovery and using waste heat from industry. Awarding of the 'Energy "Oscar" – celebrating the best energy savers and producers in the community. Developing new hydropower ideas, especially small hydropower projects. Realising the connection to the Rhaetian Railway to counter the national S-Bahn proposals. Developing new key energy policy. Developing new concepts for public lighting. Initiating competitions for engineers and architects.	Examining the use of wind on the Alp Lida. Examining the use of vertically rotating wind turbines, particularly in commercial areas. Testing and developing biogas technology. Creating a biogas cooperative for the town. Adopting the objective 'Energy Autonomy Balzers' or 'Renewable Balzers'. Creating an inclusive energy commission comprising the local energy commission, the local citizens cooperation and the local economic commission. Promoting a curriculum in schools in the areas of energy conservation and renewable energy.

Tables 26 and 27 shows that there is generally a strong willingness to pursue a variety of projects in the municipality, some of which have been in the planning for many years, and so are not at all 'new'. There is a strong trend for developing energy policies that is separate to the national energy policy, the target of a 'Renewable' or 'Energy autonomous' Balzers was even proposed. Since most of the ideas and lighthouse projects still require national level approval, their implementation may not be possible in the short-term.

To gauge the individual contributions of actors to pursue multidisciplinary action and to see whose interests and responsibilities matched, the question was then raised as to which initiative each actor would be most willing to be associated with.

The result was as follows:

Table 28. Focus areas preferred by each municipal actor.

Actors	Preferred area of responsibility
Municipal executive council	Supporting the overall process through the adoption of policies, decisions, financial assistance, etc.
Construction Administration	Organizing and coordinating the new ‘Energy Table’ (“Energie(stamm)tisches”).
Local Energy Commission	Organising primary coordination and communication. Developing energy concepts. Re-auditing for the Energy City label. Implementing activities - “Involved in everything”
Local Environmental Commission	Advising and supporting the implementation of the Energy City measures. Developing a school program on energy.
Local Economic Commission	Promoting communication and information exchange. Creating information points. Sensitizing stakeholders. Creating incentive systems for industry to do the right thing. Developing economic strategies such as expanding the promotion of green businesses.
Energy City Advisor (Lenum AG)	Re-auditing for the Energy City label. Updating energy targets. Improving the Balzers’ energy concept. Developing measure proposals.
Liechtenstein Solar Cooperative (Solargenossenschaft)	Expanding PV potential and creating a local solar roof cadastre. Collaborating with the Liechtenstein Institute of Architects and Engineers (LIA) on water, wind and street lighting.
Liechtenstein Engineers and Architects Association (LIA)	Assisting, training and consulting of architectural and building professionals.
Citizens Cooperative Balzers (Bürgergenossenschaft)	Expanding wind, water and biomass. Maintaining communication as organizational commitment through public information projects.

Table 28 reveals that interests were often shared, particularly in communication and collaborative measures. Sensitisation projects was supported by the municipal groups and the local citizens’ cooperative, in form of events, educational programs and economic strategies while the external groups preferred to develop planning tools or focus on the implementation of specific energy projects.

There was a realisation amongst the municipal actors that before this workshop, actors, including those who were only *indirectly* associated with energy, had never previously sat together to discuss energy questions as a group. This sense of inclusiveness and togetherness was much appreciated and was reflected in the positive comments on the workshop process, as documented in the feedback survey.

Overall, the workshop showed that there was no single person responsible for coordinating the implementation of the municipal energy strategy in Balzers. The external energy consultant Lenum AG had developed the catalogue of measures but as for the operationalisation of measures, there was no coordinator or overseer to ensure that measures were acted upon. The projects implemented so far are carried out by different parties, achievements of which have been individually gathered and collectively reported to Energy City.

Besides the mayor, who left early in the workshop, indicating his trust in those responsible for energy to act on his behalf or given the lack of available time, another individual showed promise as a potential associative leader: the current director for municipal energy. There is potential in this individual to act as overseer and champion of a municipal energy strategy with energy autonomy as a target, to shore up support, and to mobilise the community into action. But despite the given position of power in heading the energy domain, the workshop revealed that powers to pursue implementation has been used in a characteristically quiet and pragmatic way, cautious to avoid of transgressing boundaries, or moving beyond the general consensus. The capacity to tie together a comprehensive strategy like energy autonomy requires an individual who is sufficiently inspired, knowledgeable and charismatic, beyond that of the role of an administrator. These are the qualities that have the potential to be developed. Indeed, the workshop revealed that what was really missing was someone (or something) to drive things forward more assertively.

It is interesting to note that representatives from the national utility LKW and the Energy Office (Energiefachstelle) were (possibly consciously) absent. This was fortuitous in clarifying discourse since their presence might have dampened frank discussion amongst the municipal actors.

Findings from the feedback survey

A follow-up survey was sent to the workshop participants (n=12) - excluding the academics from the universities and external technical experts – in order to gauge opinions on the workshop process and to pose further questions regarding the potential for energy autonomy in Balzers and the assistance the municipality required to pursue the goal. The survey combined likert-scale and open-ended response questions.

At the end of December 2013, 7 out of 12 had replied, with responses as follows:

1. Which aspects of the workshop were useful to you?

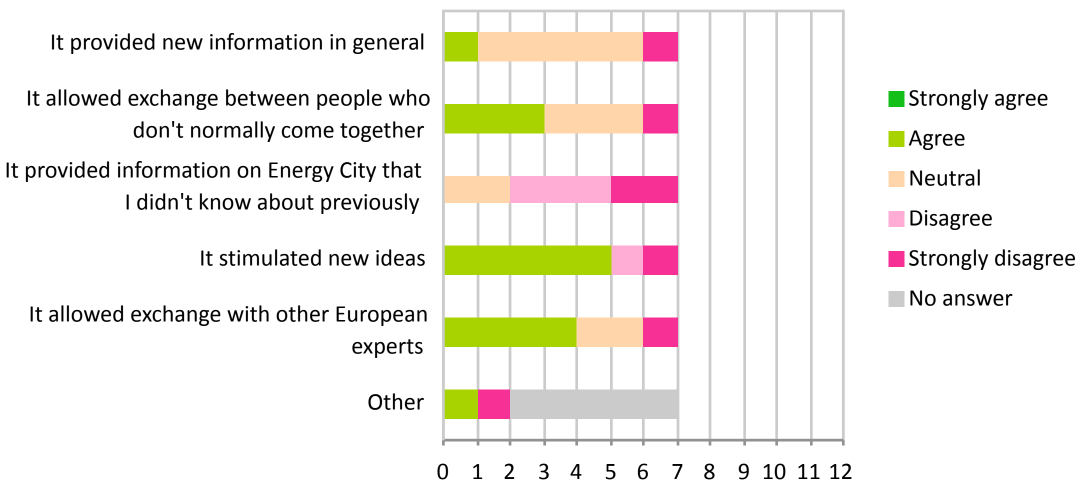


Fig. 135. Number of participant responses to the useful aspects of the workshop.

Most of the respondents highlighted the ability of the workshop to stimulate new ideas, followed by appreciating the exchange with experts or academics. This shows a still willingness to embrace new strategies and ways of thinking. The exchange with people who do not normally come together was also appreciated, with one representative from the Citizens Cooperative (Bürgergenossenschaft) noted the workshop's ability to advance their sense of togetherness and collaboration. Most of the information on Energy City was already known to them, which reflected how well the program has been in sensitising all parties. Many respondents also greatly appreciated the new information that was provided to them, which shows that the municipal representatives welcomed the opportunity to learn more and advance their own knowledge.

2. How will you apply what you learnt in the workshop?

Respondents generally noted that the ideas discussed would be introduced back to each of their respective areas of responsibility - this was stressed particularly by the representative of the Citizen's Cooperative. Two respondents agreed on improving communication in the community with the local energy commission, and information dissemination with respects to the creation of an 'Energy Table' (Energietisch). Because implementation was considered in the process or in planning anyhow, the information received did not trigger any additional motivation to implement more than that has been planned.

3. What do you think the next steps should be for Balzers?

A strategic, targeted approach was admittedly lacking, particularly as this was seen as the cause of the failure of initiatives in the area of mobility. Leadership was greatly needed to target the weak points and ideas that were developed in the workshop, for example the implementation of a company or corporate mobility management for industry. Target setting and vision setting was also thought to be lagging or not sufficiently ambitious despite the 2000-Watt targets that were in place. Clearer targets and involvement in the local energy supply were considered essential, but measures should not just be planned but also prioritised. According to the representative of the Liechtenstein Solar Cooperative, transparency in the management of the local electricity and gas supply is needed. For this actor and the representative of the Citizen's Cooperative, a working group can only function well if the municipality integrates as many interests as possible, because this was seen to be completely missing in the municipal process. Further to this was the need for further public relations to raise awareness of all energy-related activities in the locality.

4. The workshop is predicated on making Balzers energy autonomous.

   a) Is energy autonomy for Balzers possible?

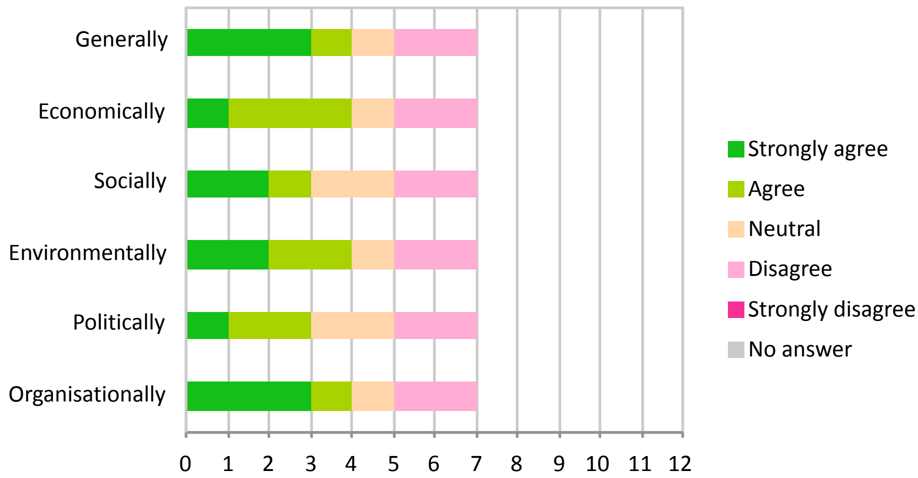


Fig. 136. Number of participant responses on the possibility of energy autonomy in Balzers.

b) Is energy autonomy for Balzers desirable?

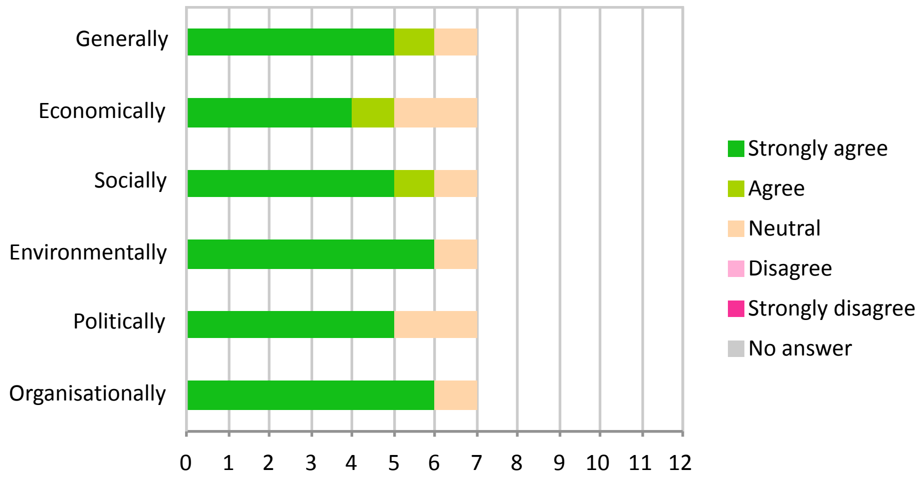


Fig. 137. Number of participant responses on the desirability of energy autonomy in Balzers.

Figures 136 and 137 show that energy autonomy for Balzers was generally considered more desirable than it was perceived possible. Although cost was usually the first concern, the possibility of achieving energy autonomy was seen to be more remote in political terms than in economic terms. Respondents viewed the greatest possibility for energy autonomy though organisational changes. Generally, the vision was considered equally as important for the organization as for the environment. The economic benefits of energy autonomy were deemed least significant relative to the other factors.

5. Any further comments regarding energy autonomy for Balzers?

The vision of energy autonomy was unanimously supported but according to the participants, it would require strong financing frameworks and robust framework conditions to shore up 'political will'. According to a representative of the Citizens Cooperative, the vision should not be pursued “at any price... cost and efficiency have to be economically feasible and carry themselves.” The representative from the Solar Cooperative also warned that energy autonomy must mean the sharing of profits and energy surplus for all of those involved in their production, not only for the utility or specific groups or individuals. Citing the example of the national utility LKW and the sourcing of hydropower, profits from energy generated have not been refunded or compensated to the owners of the land through which the water ran through. The municipalities of Triesen and Balzers for instance have not been paid part of the profits from the hydro electricity sales derived from their localities. The utility has not even been compelled to pay any water charges or fees.

6. Would you support making 100% renewable energy self-sufficiency as an official local government target for Balzers?

Six out of seven would fundamentally support the vision as a target for the municipality. Only one person would support it also as a target for the whole country, arguing “in the context of the whole world becoming energy autonomous, the cycles of nature should be taken as an example or else I see in the long-term no chances for survival for humanity.” Two respondents preferred it as a regional target encompassing the entire Rhine Valley. Another reminds that it can only be target if it makes economic sense, in that the notion of the “uneconomical prestige project” (or white elephant) should be avoided. For the one individual who did not support energy autonomy as a target, the preferred focus was rather to achieve the necessary compensation for the electricity produced in and by the community, giving the example of the large photovoltaic arrays on agricultural farms in Balzers. For this person, energy autonomy has the risk of potentially nurturing monopolies and mini-cartels on renewable energy and therefore the sequestration of profits into private pockets.

7. What kind of further assistance would you like to see from the national government to allow Balzers to pursue their own energy program and projects?

Generally, continued financial support was essential however respondents interestingly asserted the need also for a *change of attitude and focus*. In terms of attitude, respondents remarked that the national government must be more positive, play a stronger leadership role, be more open, and have faster decision-making processes. At the same time, the national government should be able to temper the control of the national utilies over local energy supply systems and allow the municipality to maintain its own local energy advisory service. In terms of political support, the focus should rather be on initiating programs to advocate no nuclear electricity, projects to partner with neighbouring countries such as Switzerland on wind power, schemes to expand its energy advisory service, and initiatives to promote more think-tank events. For two respondents, the consistency of support from the national government has been questionable. The local wood-fired power plant in Balzers for example, took three years to gain national approval, a period considered unacceptable for its local initiators and operators.

8. Which entities would you like to see the municipality cooperate more with?

Most (6 of 7) considered continuing collaboration with the national government necessary. However they also supported increased participation with the national utility LKW (6 of 7), local citizens including work with neighbouring municipalities (4 of 7), and the Solar Cooperative (2 of 7). Other important partners mentioned included the national gas utility LGU, the rest of the municipal council and mayor, local banks and national offices or foundations responsible for education and housing. Another important suggestion related to the need for a local energy committee that was more inclusive. The current municipal energy committee was seen by several respondents to be only for the decision-making of designated members of the municipal administration. the representative of the Citizen's Cooperative reminds: "one has to focus and bundle the interests… [and not to] foster small-minded local interests of a few."

Balzers and the Energy City framework

The potential to optimise energy efficiency and generate local renewable energy is already well documented as evident in the analyses and reports developed by external energy consultants to Balzers, Lenum AG. The local government have at their disposal energy targets until 2100, calculations on energy consumption for heating, electricity and mobility per capita broken down according to energy source; water consumption, carbon emissions, renewable energy generation potential; all accompanied by a list of recommended measures. It also has an energy efficiency map, energy supply map, energy planning/structure map (Energierichtplan) and an energy cadastre map (Energiekataster).

The municipality has improved by five points in its Energy City score between the years 2009 and 2013 through consistent reviews of projects, mapping and concept development. Table 29 shows that the main achievements in the four-year period have been largely associated with strategic planning. In other areas stipulated by the Energy City framework very little has improved. There have been no 'lighthouse' projects or progress in mobility measures.

Table 29. Achievement of measures in Balzers (Adapted from Balzers Municipality, 2009, 2013).

Measures	**2009**	**2013**
Energy City Score (%)	54	59
Spatial planning		
- Mission statement (Leitbild)	Not implemented	Implemented
- Municipal energy cadastre with indicators (Energiekataster)	Planned	Implemented
- Municipal energy structure plan (Energierichtplan)	Planned	Implemented
- Municipal energy balance with indicators (Energiebilanz)	Planned	Implemented
- Municipal traffic plan (Verkehrrichtsplan)	Implemented	Implemented
- Municipal wide energy potentials study	Not implemented	Not implemented
Municipal buildings and facilities		
- Energy accounting	Implemented	Implemented
- Renovation strategy	Implemented	Implemented
- Energy certificates	Implemented	Implemented
- Purchase eco-power	Implemented	Implemented
- Building in Minergie-P Standard	Implemented	Implemented
- Optimise street lighting	Implemented	Implemented
Supply and disposal		
- Solar PV or thermal on public buildings/ structures	Implemented	Implemented
- District heating/ or wood chip for municipal buildings	Implemented	Implemented
- Small water power (run by LKW)	Not implemented	Not implemented
- Biogas	Implemented	Implemented
- Waste water treatment with latest standards	Implemented	Implemented
- Establish waste heat potential of industrial area	Planned	Not implemented
Mobility		
- Parking space management incl. pricing	Not implemented	Not implemented
- Network of pedestrian paths and bicycle routes	Implemented	Implemented
- Speed limit zones	Not implemented	Not implemented
- Mobility management for municipal administration	Not implemented	Not implemented
- Design of public space	Implemented	Implemented
- Bus tickets, public transport, taxi service	Implemented	Implemented
Internal organization		
- Established energy commission	Implemented	Implemented
- Activities program	Implemented	Implemented
- Budget for municipal work in energy (CHF/capita)	19	22
- Special financing models with solar cooperative and LKW	Implemented	Implemented
- Procurement guidelines	Implemented	Implemented
- Investment in ecological funds	Not implemented	Not implemented
- Performance agreements	Not implemented	Not implemented
- Further education of municipal employees	Planned	Planned
Communication and cooperation		
- Subsidies for energy efficiency and renewable energy	Implemented	Implemented
- Free energy advisory services for citizens	Implemented	Implemented
- Promotion (eg. Internet, TV, Newspaper, Energy week)	Implemented	Implemented

Implemented   Planned   Not implemented

It is important to note that the Energy City indicators had changed between the two assessments of 2009 and 2013. Simplified from 90 to 87 criteria, the major changes predominantly concerned Section 1 'Strategy and Planning.' For this area, reports had to be more diligently made and be more exhaustive and reflective. According to Lenum AG, communities, which reported in 2009 but did not change, or improve in their energy efforts, was 7-8% worse in the following evaluation. With this in mind, it is interesting to note that Balzers was still able to increase its score by 5%. It is also significant that the extra weighting on 'Strategy and Planning' may reflect a changing attitude by Switzerland's Energy City in acknowledging the growing importance of spatial planning measures. This is underscored by revised Swiss spatial planning regulations, which stipulate that planning permissions are no longer required for solar installations, while the installation of systems now take precedent over aesthetic concerns (Spatial Planning Law, 2014).

This section has revealed that local government awareness for energy autonomy issues and capacities in Balzers is significant, however the understanding of its true economic costs and benefits was low.

6.4.3 Factor 3: Local government discretion

As described earlier, the municipality's energy strategy and climate action plan sets out self-directed measures required to achieve self-imposed short and long-term energy targets, as per national and 2000-Watt goals. The capacity to implement these measures within the confines of the Law for Local Government (Gemeindeordnung) is set out by the national government. Even though energy is not defined as formal task for the municipalities of Liechtenstein, this law at the very least, upholds the political autonomy of local governments to carry out projects however they see fit as long as they adhere to national policies.

Energy targets for municipalities in Liechtenstein are generally non-binding. However, the local building code and structural (zoning) plan specifically binds all local land-owners and residents to urban development rules that have been designed to reduce energy consumption, improve energy efficiency, encourage renewable energy generation, and promote climate protection. The Balzers Building Code (Bauordnung) (Balzers Municipality Building Code, 2011) for example, requires:

- low-energy or passive house standards for new municipal buildings,
- compact designs and higher densities,
- good insulation and additional requirements for energy efficiency,
- increased natural ventilation,
- favourable orientation of buildings,
- greening, nature conservation and tree preservation,
- filtration of rainwater,
- reduction of soil sealing,
- special rules for car-free zones and local pedestrian zones, and
- restrictions on the number of parking spaces.

The above aspects determine the success of planning permits and energy performance certificates, the tendering of architectural projects, and the sale or rent of private buildings in the municipality.

Renewable energy supply (solar panels, biomass, PV), district heating and district heating connections are promoted by the municipality but not mandated for local residents or businesses. Planning permission and building control are referred to and managed by the national Building Department, and examined according to the national energy laws. External experts would also review the permits.

Since 2007, a building energy certificate for new buildings has been required for buildings with a volume over 2000 m^3. All building inspections are usually followed by an energy examination. Since authorisation and control is carried out at the national level, the local government has limited impetus to optimise building development that achieves more visionary energy targets. Except for requirements that all renovations of public buildings must be to Minergie standards, national assessment and policing procedures have not motivated the development of more advanced rehabilitation concepts for all buildings by the municipality.

The local government of Balzers do however have at their disposal local regulations governing the renewable energy technology installation and assembly, in particular solar thermal collectors, photovoltaic systems and other alternative power generation facilities (Rules of Balzers Municipality for Energy Recovery Systems, 2013). Although the regulations stipulate where installations can and cannot be built and positioned, how these are to be integrated and in what form (as per the instruction “a uniform design is to be achieved” (Art.2), is basically addressed. Rules for installations on roofs and facades in relation to solar thermal and photovoltaic systems for example refer to required pitches, surface area, and mounting. There are however no supporting illustrations as to what this means in real design terms. Like most municipalities in Liechtenstein, systems are banned in historical village areas, in public spaces, on the ground, and on fences. Installations not usually allowed can be given special dispensation if designs are justified and have been assessed on a case-by-case basis. Although these rules sit as a separate code to the local building and zoning codes, they are statutory in Balzers.

It is important to note that Balzers' zoning rules is more advanced than other municipal zoning strategies since it is the only municipality to have a zone type dedicated specifically to energy and which is accompanied with a special article explaining the zone in its local building code. (See Table 30).

Table 30. Code for energy supply in Balzers

Code
Article 20 - Zone for energy supply (EV): In this zone energy supply structures and equipment are allowed, but when the buildings and grounds are inoperable, the operator is obliged to cancel the buildings and grounds and to restore the site. (*Balzers Building Code*) Article 3 – Principle 1.Systems affecting the local and cultural landscape, including natural monuments and traffic safety must be assessed in each individual case. 2. No attachments are allowed in the garden, on surrounding walls, fences and the like that goes over public space. 3. Systems (solar panels and photovoltaic) in the terrain must be assessed in each individual case. 4. Systems (solar panels and photovoltaic) in conservation zones are not allowed. Article 4 – Solar thermal and photovoltaic systems 1. Solar panels and / or photovoltaic systems must be integrated into the roof surface. Only in special cases (substructure of the roof surface, such as sandwich structures, sheds), or if the roof flush installation would mean a disproportionate effort, are exceptions possible. The overall roof surface must not exceed 20 cm. 2. In core zone K, village core zone DK, village zone D and with new buildings in all zones only roof-flush, integrated systems are allowed. Surfaces that can be seen from the public domain are to be judged in individual cases. 3. The collectors have to have the same surface inclination as the inclined roof underneath. The horizontal lines and side borders/edges as special visual characteristics of building are to be paid attention to. For a good integration of a solar collector or photovoltaic system into an existing structure, it is important to respect the contours of a building. The modules must not extend beyond the building contours (outlines/profile/shape). Connection lines are to be integrated into the new construction. Existing buildings and renovations conduits at facades are to be carried inside a tube or a clean cover (analogous to rain water drains). 4. For flat roofs, structures on stilts are allowed but design measures are to be taken (eg high roof edge, positioning the system in the centre of the flat roof etc. the different fields should not be mounted higher than

140 cm and in a suitable distance from the roof edge. Field heights higher than 140 cm are only possibly when argued sufficiently and in writing.

Article 5 - Facades
1. In the village centre zone and village zone, energy recovery plants on facades are not allowed.
2. In other residential zones, systems are to be installed flush with the edge of the facade. The collectors should be integrated into the façade, for example to components such as window sills, balcony railings, etc., and should fully cover the surface.
3. The plants are preferably affixed to surfaces, which face away from the public space.

Article 6 - Wind power
1. Small systems (up to 5 kW) are not allowed in the residential zones A, B, in the core zone K, Village core zone DK, village zone D and the residential zone WA. From the standpoint of local structural conditions and protection of the landscape, small wind turbines are possible in other zones. All requests must be submitted to the building authorities for evaluation.
2. Large plants (5 kW) are subject to a special approval process.
3. Wind turbines in the landscape protection zone and the LS Conservation zones are not permissible.

Article 7 – Development control plan
1. In a development for alternative power generation facilities, a redevelopment plan that shows the concept should be established for the entire redevelopment plan perimeter, showing the product, the arrangement, colour etc. The concept is to be submitted to the authorities for assessment before a building permit is issued.

(*Translated from Rules of Balzers Municipality for Energy Recovery Systems, 2013).*

The municipality has established energy and procurement guidelines for municipal property. New municipal buildings should at least be Minergie standard, but Minergie-P, Minergie–A, or the use of 100% renewable energy is encouraged wherever possible. Through the Swiss collaborative sustainable construction platform eco-Devisbau (http://www.eco-bau.ch), an expert for advice on building ecology is provided by the municipality. But despite such guidelines, there are still no new municipal buildings which have achieved high energy performance, or any optimised energy upgrades performed by the municipality. Instead, the municipality has focused on sourcing local energy through small district heating plants and photovoltaic arrays on municipal roofs or simply compensating energy consumption with externally procured green power for all municipal buildings except for the rented buildings such as the homes of the elderly. Since 2012, the municipality has supplied its own heating for municipal buildings with 20% biogas and 80% natural gas. Nine buildings are connected to the local district heating (Fernwärmeverbund), of which 58% of the energy is renewable.

The municipality has in place an energy accounting system of all community-owned buildings and facilities, certified though energy performance certificates. The energy inventory accounts for heat, electricity and water consumption, the data of which is collected by caretakers and is calculated using the EnerCoach software by an external energy specialist. The energy accounting is discussed further with property managers and caretakers in detail. The final results are communicated to the community. Despite the data serving to prioritise actions and optimise measures continuously, operational enhancements have not been performed in Balzers within the last four years (2009-2013). A remote reading system for heat meters in municipal buildings was installed but smart metering has yet to be employed to control energy consumption.

The municipality procures renewable energy through supply agreements with the national electricity provider LKW, but the association with the LKW ends there. There has been very little engagement with the utility since the LKW is not obliged by law to collaborate with local governments in the planning of local energy supply networks. While the municipality has no direct influence on LKW or LGV, the national natural gas provider, the utilities and the rest of the national offices in comparison have a great deal of say on what the municipality does. The construction of any new municipal district heating networks or independent power and heating plants have to refer to the national government for approval, as well agreement from the energy providers. This has consequently slowed down the implementation of local energy projects. In Balzers, it took three years to gain State approval for one wood fire biomass plant.

It has also been difficult to intervene in areas within the locality, which are not directly owned by the local government. For example, the municipality has had no voice or influence over the functioning of the local home for the elderly, which belongs to the local Citizens Cooperative. It does not have jurisdiction over the medical buildings belonging to LAC Foundation (Liechtenstein Foundation for the Elderly and for Medical Assistance). Influencing school curricular to incorporate the education on energy matters has also been limited to primary schools since high schools were not a municipal responsibility but the responsibility of the national government.

In terms of energy advice, this has been provided directly by the municipality, usually via the local building department, but the information provided is not as comprehensive since the local service is entirely self-funded. Local queries are almost always redirected to the national government's Energy Office (Energiefachstelle), which provide direct face-to-face consultation but also awareness-raising through seminars, events and a website (http://www.energiebündel.li). On the other hand, local budgets have been made sufficient for the granting of local subsidies to support the renovation and construction of buildings with high energy performance, a complementary measure to national subsidies, which have thefore created a greater incentivised environment for local building owners and developers.

Generally, the municipality of Balzers has largely engaged traditional urban planning methods to control local energy consumption, especially in mobility. Since 2012, mercury vapour street lamps have been replaced by LEDs, and streetlights on local roads have been switched off at night from 00:30 to 05:30. There are charging stations for e-bikes and e–cars, incentives for carpooling, EcoDrive training for residents, instruction in the rules of municipal employment that encourages public transport and the use of Flexi Cards (for discounted rides), covered bike parking spaces in front of major public facilities, and shower facilities in the parish hall. However, no car park management system exists (other than temporal restriction of some places to 12 or 24 hours). This is in contrast to the local industries (Inficon, Umicor, Oerlikon), which already had their own systems in place. The inability to maintain traction for projects has been an issue for the municipality, as reflected in a survey carried out by the municipality on the mobility behaviour of municipal employees, which was started but not completed.

The limited degree of discretion is also reflected in the manner the local government is allowed to participate in national decision-making. According to the Energy City reports, the municipality regularly transmits its views and positions to the national government with regard to national laws on energy and spatial planning. Tellingly, this type of feedback is classified a form of cooperation, under the Energy City theme of 'Communication and cooperation'. Yet a review of council minutes revealed that municipal involvement with national government decision-making has rather been in the form of letters that merely serve as *reactions* as opposed to real consultation. Municipalities in Liechtenstein can only 'take positions'. Local governments in Liechtenstein can write 'Stellungnahmen' in response to consultation, in a 'Vernehmlassung', a centrally administered process of quasi-public hearing procedure in the legislative process. For matters of direct interest to the local communities this may not constitute sufficient degree of participation as it does not mandate active participation in decision-making or constitute a veto right.

But despite the limitations in municipal impact from consultations, the municipality of Balzers has taken advantage of the opportunity to outline their concerns, by providing statements on for example, the revised Emissions Trading Act, revisions on the environmental impact assessment procedure, changes to the law on the protection of nature and landscape, and amendments to the Forests Act.

This section has revealed that the degree of local government discretion has been low, despite laws advocating municipal autonomy. The intervention of the national government, through the national energy providers LKW and LGV and the national Offices and Foundations responsible for education and health, has restricted and delayed energy awareness-raising and building energy improvements by the municipality. Interestingly, the municipality has been unable to keep up with its own energy performance standards, and has resorted back to small-scale traditional practices with regards to encouraging building improvements, green energy procurement, and simplified mobility measures.

6.4.4 Factor 4: Local energy potentials models

Local renewable energy potentials of Balzers have to date been examined by energy consultants Lenum AG, based on generally available information from EnergieSchweiz and the Swiss Federal Office of Energy. For the local government workshop, the University of Liechtenstein has developed a more specific and accurate picture of Balzers' self-sufficiency, expressed in a series of scenario maps based on energy calculations and GIS visualisations, supported by team from EKP and Technical University of Nordhausen (Genske et al., 2013). These maps are consistent with the energy potentials modelling used in the Renewable Liechtenstein study (Droege et al., 2012).

The local government itself does not engage in energy potentials modelling or maintain any form of energy model, except for the energy accounting and monitoring of the energy consumption and generation of individual municipal buildings.

The energy statistics determined by Lenum AG have been translated into the local Energy Cadastre (Energiekataster) and the Energy Planning/Preferred Sites Plan (Energieplanung/Vorzugsbebeiete 2012) that the municipality has since used to guide energy development in the locality. The Energy Cadastre maps the consumption of heating and electricity by colour-coding its use densities over the municipal area. The Energy Planning/Preferred Sites Plan indicates the potential areas for hydropower, photovoltaic, solar thermal, air heat pumps, and wood energy generation. The Plan also shows the preferred areas for wind energy, surface water for thermal use, wastewater for biogas, and use of waste heat. Preferred areas for district heating with renewable energy generation, such as areas with geothermal district heating are delineated. The zones ideal for combined heat and power powered by renewable sources (e.g.biogas/ wood) are shown. It also outlines the area where district heating from the KVA incinerator in Buchs may serve. Although energy from waste incineration is not considered renewable in this dissertation, the national government of Liechtenstein regards this energy to be 50% renewable since half of the raw material used is organic waste.

The municipality has also relied on other pertinent analyses to influence local energy planning. One independent study for PV electricity really drove the implementation of this technology over several years, after it was found that 86 % of the electricity demand of municipal buildings and places could be covered by such systems alone. Alternatively, analyses have acted to prevent the development of technologies, such as harnessing heating energy from waste heat recovery from local industries. In one early study that was created for the entire country on the potential of waste heat from the sewage network it was found that waste heat utilisation was “inappropriate” for communities with already established district heating plans like Schaan or Balzers. This may have influenced Balzers’ decision not to conduct analysis for the potential for waste heat recovery – a deficiency in its latest Energy City audit. This last aspect demonstrates a new growing tension between the technologies – of district heating, efficiency improvements, waste heat recovery, and ground-source heat pumps. This is waiting to, and can only be resolved at a local level through the shoring up of technical capacities to do so.

In recent years, several important local energy studies have impacted the drive to implement by the local government of Balzers. These include the numerous windpower assessments, the result of collaboration between the municipality, the Solar Cooperative, the LKW and other private partners; the groundwater exclusion zone maps for ground-source heat recovery made available via the national government's online geographical information portal; and the Renewable Balzers scenario maps, which show the energy autonomous potentials of local urban space types and which follows on from the results of the Renewable Liechtenstein study. Indeed, the majority of the wind power studies in Liechtenstein have been based in the municipality of Balzers due to its high potentials for wind energy.

Table 31. Local wind energy potentials studies in Liechtenstein. Studies for Balzers indicated in red.

Project	Year
Wind field analyses Balzers	2008
Wind measurement Balzers-Neugüeter	2008
Wind measurement Triesen Hälos	2009
Wind measurement Balzers Alp Lida	2010
Wind measurement Balzers Ans	2010
Wind measurement Balzers Fläscher Riet	2011
Wind measurement Ruggell/Schellenberg	2012
Wind field analyses Fläscherberg	2012
Wind measurement LKW	2012

It is important to note that of the studies mentioned in this section: the windpower studies, groundwater maps, and Renewable Balzers/Liechtenstein scenario maps have been placed in the public domain. Although there is a large amount of information available to inform local decision-making and project implementation in Balzers, data has informed only a few, in particular just those in charge of energy rather than the wider community. There is great potential to use the wealth of information available, to inform the public of the energy potentials of their sites and buildings in order to influence further voluntary action. This is critical if the municipal energy targets are to be achieved, since it requires action by all sectors of local society, not just local government. However, to do so requires taking stock of all the information at hand by the municipality, and then carefully consolidating and presenting the data in a manner that is useful to different community actors, without compromising the privacy of different stakeholders with regards to their individual energy consumption and generation patterns.

6.4.5 Factor 5: Local government organisational change and augmentation

There were very few changes in the organisational structure of the local government of Balzers when the municipal council decided to pursue the Energy City accreditation. It created its own Energy Commission and an Environmental Commission, with councillors and administrators represented in both groups. The commissions would decide on policy and targets, met four to six times per year and proposed implementation measures. They conducted annual success monitoring, and regularly communicated the activities of the municipality. Committed citizens were also allowed take a seat in the groups.

Energy-related projects throughout the municipality were implemented on a case-by-case basis, by different parties (the council, citizens cooperative, private business, industry or households) and followed standards set by local building and zoning regulations. There were special project teams set up for special projects. The energy projects would then be matched up to the catalogue of measures defined by the Energy City framework for monitoring and reporting purposes. All activities underwent standard planning approval procedures, which were undertaken by the national building department.

Within council, energy topics and proposals received were regularly discussed with personnel. The responsibilities of the personnel were also defined and documented. No recognition or special credentials were however given for special achievements or energy-related performance agreements. However the local government does provide opportunities for further training in building energy and facilities management.

Augmentation was achieved by the local government, through partnerships with public and private entities. To create the initial municipal energy action plan for example, with set targets and activities based on the analysis of energy consumption and production data, external energy consultant Lenum AG was contracted to carry out the work. The company is incidentally responsible for almost all of the local energy strategies throughout Liechtenstein, and has also been responsible for the majority of Energy City audits. Other major partners have been the Liechtenstein Solar Cooperative (Solargenossenschaft) and the Balzers Citizen's Cooperative (Burgenossenschaft). The first group has been active for many years in the municipality with regards to assessing local wind power, while the second group has worked actively in advocating the displacement of power lines, though primarily for reasons of landscape protection.

Cooperation with other municipalities has been acknowledged as an achievement according to the Balzers' Energy City audits. However the extent of cooperation has been limited to regular *events* such as the monthly Liechtenstein mayors' meeting (Gemeindevorsteherkonferenz), the Energy City experience exchanges with local governments in the Alpine Rhine Valley area, and the cross-border Agglomeration Program. There have been very few collaborative projects related to the construction and operation of specific energy technologies or systems. Meanwhile, existing partnerships may not be producing the most environmental results as perceived. As an active member of the Liechtenstein Timber Association (Verein Holzkreislauf), which is a country-wide wood industry association, the municipality considers this partnership critical towards promoting the use of forestry-based wood products for construction and heating. However, the use of this resource for heating is questionable since it has taken precedent over the use of recycled forestry, agriculture and household plant *waste*.

Despite this, other partnerships have been critical to local success. Links with the national government have been consistently maintained through the national Energy Office and other State Offices (Office of Environment, Office of Civil Protection, Office of Forests, Nature and Landscape, and the Civil Engineering Department). The municipality regularly sends their opinions to the national government with regards to national laws on energy and spatial planning, but this is largely done on a voluntary basis.

Balzers' own economic commission maintains dialogues with local businesses and industry through regular visits. Mobility management programs for local companies are discussed - although the municipal itself does not boast one itself. There are no special cooperation programs in the field of energy efficiency. Awareness raising measures in the community are carried out through public information events such as the biannual Energy and Environment day, the 50-year anniversary of the local waterworks, the weekly market with regional products, bicycle days, and driver safety events. Despite these efforts and based on the Energy City audits, overall municipal communication has not been entirely successful. Energy awareness, behaviour and use projects in local schools have been absent, particularly in high schools since they are the responsibility of the national government. Community feedback has not been sought since the development of the 1997 "Metanand för Balzers" strategy, which had actively incorporated citizen input.

This section reveals that there is scope for some internal organisational change, but not in the establishment of a new commission or energy autonomy task force. However the simple assignment of a leadership figure, who would be responsible and accountable for the overall coordination of the groups and activities that have or are taking place, is essential to achieve energy autonomy. He or she could initiate new partnerships, or rearrange combinations of local parties to suit the implementation of necessary projects.

6.4.6 Factor 6: The role of the national government

National energy laws have provided strong promotional and financing frameworks to incentivise energy efficiency and renewable energy projects within the municipality. Until early 2013, feed-in tariff laws had significantly boosted local generation of photovoltaic electricity. National building regulations and planning processes further facilitated the implementation of energy technologies. Like most building applications, projects which involve energetic improvements or integration in new-builds are similarly submitted to the local building department, which are ultimately referred to the national building department for construction approval. Construction is monitored and energy performance is measured and reviewed. Rebates are distributed via the national Energy Office, determined by the energy performance certificate issued. It has been noted however that the Energy Office has too great an influence on what is advised and promoted by the municipality in terms of the technologies and investment mechanisms, which may have caused some systems, which may be less cost-effective in the long-run, to be preferenced over others.

National influence is further reinforced in the control of the energy supply network in the municipality and throughout the Principality by the two national providers for electricity and gas (LKW and LGV). They control what energy comes in and out of the municipalities, the energy mix, procurement policies, construction, operation and maintenance of distribution networks and supply contracts. Through the LKW, the municipality of Balzers has procured green electricity LiStrom Natur, which has enabled the local government to claim an increase of renewable energy use in its total energy consumption, and the active replacement of fossil fuels and nuclear energy with RES. For certain renewable energy technologies, installation and supply contracts have been negotiated for photovoltaic arrays on municipal roofs. However, systems that are separate from the established energy supply network have been more difficult to gain centralised acceptance and fair terms. For example, the long periods needed to gain approval for Balzers' new wood fire biomass plant was largely attributed by the local councillors to concerns raised by the national gas company LGV, during the assessment process. A certain unfairness in renumeration was noted when farmers and landowners were not sufficiently compensated for the electricity generated and stored in hydropower plants that crossed their land. With regards to electricity production on farm roofs, it was also noted that LKW had ignored this as another viable source of energy production and revenue for farmers.

The national government's jurisdiction over public services of higher education and health, which include the control of the buildings and infrastructure to support such services, has made municipal intervention into implementing energetic improvements and awareness-raising of energy issues difficult in high schools and universities, while monitoring and energy-retrofitting of local homes for the elderly has also been unworkable.

Meanwhile the lengthy centralised approval process, tightening budgets, and prioritisation of *national* ventures have generally thwarted the implementation of energy projects by the municipalities in Liechtenstein. In Balzers, the push by the Solar Cooperative to actually begin installing wind turbines in Balzers was delayed by the decision of the national power provider LKW to conduct its own wind power studies. This was despite the many studies that already existed and which were carried out by external research offices and universities (mainly Swiss and Viennese entities) since 2008. Another instance was the rejection of the Solar Cooperative’s proposal to the national government to extend central funding for more studies, in part due to the financial crisis in 2008. Meanwhile, it has been questionable as to whether the national government of Liechtenstein was really willing to collaborate on regional energy ventures, if it was not the initiator and leader of the project, in the light of a recent offer by the regional energy interest group Rii-Seez Power through the Liechtenstein Solar Cooperative, being rejected by the national Energy Office to take part in a newly developed regional solar energy register (created in September 2013). With the participation of the Interstaatliche Hochschule für Technik NTB in Buchs, Switzerland, the regional group had developed a publicly accessible online solar cadastre for member municipalities in Sarganserland and the Alpine Rhine Valley (http://www.riiseezpower.ch/Produkte/Solarkataster/tabid/179/Default.aspx). But when an invitation to join the cadastre was extended to the national Energy Office, the response was that Liechtenstein’s participation was not needed. Yet in that same year, there was a request from the national electricity provider LKW to the University of Liechtenstein to create its own countrywide solar cadastre.

Although the national Energy Strategy 2020 provides another point-of-reference for municipal administrations in Liechtenstein, the local government workshop revealed that it has not been a major influence on actual municipal activity in Balzers. There has not been extra movement after the Strategy was revealed. In fact, Chapter 5 showed that the measures targeting local governments were activities that the municipalities were already undertaking. Although 18 of the 47 measures recommended in the strategy have been slated for inclusion in the national Energy Efficiency and Renewable Energy Act (EEG, 2008) - actually reaching the EU targets of 20-20-20 (20% emissions reduction, efficiency improvements and renewable energy share) enshrined in the Strategy will require more active forms of implementation, including the engagement of local governments in the implementation process. Indeed, the Solar Cooperative's own evaluations had found that the proposed changes to the EEG law will not be sufficient to reach the 20-20-20 targets, which lends to an uncertainty as to the commitment by the national government to the Strategy.

This section reveals that the influence of the national government was more significant than the municipality has perceived, even despite its insistence on municipal autonomy. National government intervention in form of national policies and laws has generally played a positive, commanding role, but national intervention though its energy providers has created a less than transparent, uncertain environment for local governments to contend with when pursuing their own energy projects. The national energy companies are not legally obliged to include the community in its energy planning, nor can the municipalities participate in their decision-making. Meanwhile the emphasis of nationally led projects over independent local activities or even regional collaborative work does not lend to an environment where energy activities are shared, developed and nurtured, essential to the pursuit of energy autonomy.

6.5 Discussion

6.5.1 Response to Research Question 5

Research Question 5 as formulated in Chapter 1 stated:

'How can the recommendations for energy autonomy in Liechtenstein be implemented within the context of actual local government capabilities?'

Taking the local government of Balzers as an example, the implementable aspects within municipal capabilities relate to their discretion to formalise energy autonomy goals as local policy, to revise local building and zoning laws, to lead and mobilise community participation, and to engage with pertinent national authorities in the planning of the local energy supply network. The first aspect concerns the values and the politics of the place, the second concerns legal requirements, the third concerns participatory frameworks, and the fourth concerns centralised rules of engagement. The first appears to be the most difficult action to pursue due to the mismatch in direction between the goals and targets of the national government compared to those of the local government. Since there is implicit support for energy autonomy amongst councillors (in 2013), it may only be a matter of time before the concept is institutionally adopted at the local government level, despite the more moderate centralised targets. The second legal aspect in amending local building and planning laws is gradually taking place in Balzers. Strengthened legal frameworks can provide a more certain basis for implementing a range of energy projects necessary for the pursuit of energy autonomy, engendering a sense of stability in activities that are institutionally sanctioned. The third aspect of community engagement has so far not been pursued to the fullest in the municipality of Balzers, in relation to local energy activities. There is scope to strengthen collaborative work with existing partners and seek out new cooperation with the rest of the community. The Solar Cooperative and the local Citizen's Cooperative can serve as effective community mobilisers, while the identification of pertinent local leaders can help lead coordination of the relevant actors and activities. Indeed, for Balzers to pursue energy autonomy, the onus cannot be placed squarely on municipal-owned projects as weighted by the Energy City framework, but to equally allow the local community (households, businesses, industry, individuals) to participate, run or even take over control of their local energy systems. Lastly, the fourth aspect in enabling local government to actively engage with national bodies responsible for local energy, particularly the national utilities LKW and LGV, may require changes in legislation to allow for feedback and voting rights. The utilities may face the greatest challenge if they are to become more transparent and obliged to consider community feedback in their decision-making.

6.5.2 Testing Chapter 5 recommendations for local governments on the municipality of Balzers

Reframing local energy concepts

There is scope for the municipality of Balzers to reformulate their existing energy strategy to incorporate energy autonomy as a possible long-term goal. Time frames can be extended beyond the 2000-Watt target to 100% renewable energy self-sufficiency. The revised strategy can in the meantime present a desirable vision for Balzers, a marketing or communications tool to familiarise the community with the concept of energy autonomy, and to temper local concerns of its practicality and cost; therefore preparing the municipality for the eventual pursuit of a 100% renewable energy target. The local government workshop indicated that there was a general support for energy autonomy as an abstracted vision, rather than as definite energy target. By incorporating the goal as a guiding vision or image (Leitbild) rather than as a purely technical strategy, can energy autonomy slowly capture the community's imagination.

Indeed, there is tremendous scope for energy autonomy to become identifiable with the municipality. The goal is consistent with the local identity, which harks to past agricultural self-sufficiency and political independence. The municipality's aspirations for a community, which enjoys a high quality of life in a safe and healthy environment, and one that strives to maintain a strong identity based on the rural landscape tradition of self-help, matches with the 100% principles. Energy autonomy as part of Balzers identity can therefore be promoted through the creation of a 'Renewable Balzers', part of the 'Renewable Liechtenstein' – the future energy autonomous Principality.

It is important to note however that despite the positive consensus about energy autonomy amongst the administration, the real issue for the local government is whether the vision *complies* or is able to *coexist* with national level policy and targets, which are based on regional or international goals (Energy City's 2000-Watt and European Union's 20-20-20). The vision of energy autonomy is a desired idea and deemed the "right thing to do", but the willingness to act upon this vision will be hampered by the issue of political priority, more so than economy or even society. Maintaining consensus on what should be done and adhering to targets prescribed by the national government has historically influenced the likelihood of energy projects being implemented, and therefore the pursuit of energy autonomy in Balzers may be similarly affected. For the local decision-makers at present, to go beyond what is accepted, however more effective it may be, is a perceivably risky proposition.

Revising existing or commissioning new local planning tools

There is some indication that the municipality is willing to modify existing land-use planning and building codes to integrate rules governing renewable energy technology installations, especially since it is the only municipality in the Principality that has stipulated a special zone for energy production. The municipal workshop has also shown that support is high for the creation of new guidelines for households, businesses and industry with regards to RES technologies that supplement existing codes. However, to commission a publicly accessible energy potentials modelling tool that maps and codifies the energy efficiency and generation potentials, cost and available subsidies by building parcel or area, was found not to be within the capacity of the municipality administration. This activity would require external expertise.

Indeed, to create their own simplified, publicly accessible spatial modelling system, would be a difficult task to pursue for Balzers since they do not have the scientific, technical or budgetary capacity. An online information portal that shows the potentials, cost and subsidies by parcel area is ideal but it will require regular maintenance and updating. There is however scope for the local government to collaborate with local universities and private groups to produce such analytical tools, for example, the potential in participating in the regional solar energy cadastre devised by the regional energy interest group Rii-Seez Power from neighbouring Switzerland, and in creating a guiding energy vision 'Renewable Balzers' developed specifically for Balzers by the universities of Liechtenstein and Nordhausen.

Although a municipal energy structure plan and an energy cadastre plan is in place that documents existing projects and maps energy potentials by area, these are neither binding documents, nor have they been publicly released. Rather than driving implementation, the plans have served more as reportable achievements to Energy City. Great potential potential exists to use the plans as the basis for real project proposals, especially when supported with other locally relevant energy studies undertaken by the University of Liechtenstein, Technical University of Nordhausen, Liechtenstein Solar Cooperative, and Rii-Seez Power. Similarly reports commissioned by the national government in relation to specific renewable energy potentials such as deep geothermal and waste heat recovery from local industries, as well as the national Energy Strategy (Energiestrategie 2020) should provide further impetus for local government to collaborate on landmark projects.

It should be noted however that information-overload or -fatigue can be a significant drawback to studies and analyses, which in turn can paralyse governments into action. Care must be taken by municipalities to *prioritise* what is learnt and which activities to implement.

While a new integrated energy plan with energy autonomy as a long-term vision (Leitbild) can guide existing efforts (Energy City) by using the 2000-Watt target simply as an interim step towards the energy autonomy goal, revised building and zoning codes should too be linked to the improved energy plan. The new energy plan can then not only integrate the outcomes of local energy potentials modelling but also new rules in the building and zoning code that illustratively govern the integration of renewable energy.

There is scope to improve the existing building code to explain at the very least the energy impacts of urban development changes. It can also include additional sections to guide in illustrated terms how renewable energy technologies can be sensitively integrated. Although the municipality already has separate regulations for energy recovery systems, 'sensitive integration' is not explained in practical design terms. And although changes to the zoning plan have already taken place in the stipulation of a zone especially for energy generation, there is potential to show other potential zones and networks for energy generation and distribution as provided in the energy structure plan – specific items which can be made public, as opposed to the entire structure plan, which is currently entirely proprietary.

It is most critical that this new integrated energy plan also considers the mobilisation of community actors. Dealing with the incompatibility with the Energy City process, and managing competition with other municipalities as well as approvals by the national government are corollaries of this path.

Improving own knowledge on energy matters and maintaining energy expertise

It was revealed that the municipal administration already possessed a significant awareness of their own energy potential, having access to various plans, studies and recommendations provided by energy consultants and advisors from the government (e.g. University of Liechtenstein) and non-government (e.g. Solar Cooperative) entities. But to act on such data requires their understanding and translation of the data into existing tools (e.g. plans or codes) and urban development measures (e.g. extension of the district heating network, solar array on all buildings, wind farm). To finally pursue energy autonomy, requires understanding the advantages of energy autonomy in terms of *local and* *regional value creation,* aspects yet fully understood, as revealed in the municipal workshop. Continual awareness raising is therefore essential.

Indeed, improving the knowledge on energy matters by those in charge in the municipal administration is critical in the long run, particularly as personnel and groups change. The maintenance of professional development activities in energy and the nurturing of the right individuals and groups are necessary to pursue energy autonomy. Further education and training in energy can also strengthen the *leadership* for energy autonomy. The municipality of Balzers already allows for the training of local employees on facilities management, but there is still scope for further professional development through the continual assistance from external energy consultants Lenum AG and the University of Liechtenstein. Indeed, further training of the municipal administration on energy matters was generally supported in the municipal workshop, however most preferred these in terms of information sessions and experience exchanges.

Individual municipal commissions on energy, environment and the economy are already in place in Balzers, but they currently operate as almost exclusive groups. Not surprisingly, when a round table for municipal energy or Energy Table (Energietisch) was proposed as a framework for a more inclusive working group, the idea was unanimously supported by all municipal actors. It was agreed that a roundtable could better organise and coordinate the partnerships necessary to implement the various energy projects required to pursue energy autonomy. It was also agreed that via the Energy Table, there was greater potential for strengthening and extending existing collaborations with local organizations such as the Liechtenstein Solar Cooperative and Citizens Cooperative, who could better mobilise the necessary expertise and community support.

Nurturing municipal or community leaders to drive energy autonomy

An Energy Table or any other type of collaborative platform will still require a focal figure to lead the coordination of all parties involved. Even though the mayor of Balzers does not lead or is integrated in the municipality's energy commission since the responsibility of energy is delegated to an executive councillor, there is still the possibility of closer involvement given the precedence set by other mayors in Liechtenstein who actively chair their local energy commissions. Mayors can promote the success of local energy concepts and activities and champion landmark projects. The mayor of the municipality of Balzers showed great leadership in being the only one to accept the invitation for the municipal workshop on energy autonomy. This shows interest at even the highest level of local government.

A dedicated municipal energy officer to coordinate energy targets across all departments does not presently exist in the municipal administration. However, a director of the energy commission is present, but his managerial responsibility does not extend to policing energy targets across departments, or to coordinate the construction and operation of municipal energy projects. There is potential for the director to at the very least, drive energy autonomy as local government policy, while in the long-run take up the role of coordinating new energy projects and partnerships to pursue energy autonomy in the locality. Since this individual is also a member of the executive council (Gemeinderat), it effectively ties the local energy commission to the executive body. Therefore energy issues raised in the commission can be directly and quickly communicated to the council, achieving the shortest, most immediate route of communication.

The creation of a position to oversee implementation and the achievement of targets is not however impossible. There is potential to train other councillors or members in the administration to take up the role of energy coordinator, particularly those responsible for building and infrastructure. However it is essential that this individual be provided with clear responsibilities, play a central executive role in the municipality, and be strongly accountable to and be integrated in the community. This figure may not need to be directly employed within the administration, but could be contracted independently.

For the individual/s to lead and promote the vision to the wider community, a certain level of understanding of energy autonomy capacity and issues is critical. This can only be achieved if the municipality's guiding vision (Leitbild) also stipulates the necessary qualifications and experience in energy and the environment.

The three critical actors identified in the energy autonomous cases of Chapter 4: the mayor, the technician, and the communicator; are not all present in the municipality of Balzers. Mayor Arthur Brunhart demonstrate good qualities to lead a municipal energy autonomy vision, while the director of the local energy commission has the necessary experience in local infrastructure and the social connections to lead the community mobilisation process. However, the technical leader responsible for overseeing the implementation of the various energy technologies required still needs to be identified.

Currently, Lenum AG as contracted energy consultant assists in the development of the municipality's energy concept and provides auditing work and recommendations on practical measures. However, they do not actually initiate or manage the operationalisation of local energy projects.

Leading figures who can raise awareness to the wider public is essential to enable the municipality to discuss practical proposals that prioritise community concerns and aspirations, and to create strong partnerships for the implementation of energy projects without direct municipal intervention based on the matching of community stakeholder interests.

Taking advantage of the right to municipal autonomy

Although several actors in the municipal workshop commented that they would not support energy autonomy if it did not benefit the entire community or if it only benefited a few, the issue of economy for the local actors was not as critical as the political situation. The analysis showed that the level of discretion by the municipality is not as great as it perceives or desires it to be, despite the existence of a national law and a provision in the constitution that assures municipal autonomy. National level 'interference' is omnipresent, largely to provide leadership and maintain consistency in approach throughout the Principality. However, local energy supplies are still bound to national level approvals, and influence of the electricity and gas providers, which are wholly nationally corporations. Municipalities can comment on revisions to national laws and policies, but these serve as reactions, rather than as rights to veto. When local governments are determined enough to carry out their own projects, these are subject to comments by the national government, and especially the energy providers. Indeed, the opinions of the utilities have carried more weight than those of the municipality, and have served to delay local projects. This has affected for example, the timely construction of the local biomass plant and local wind power in Balzers.

Local discretion has therefore been restricted to traditional urban development tools and practices - maps to record the state of implementation and areas of potentials, local building laws to define best energetic practices, and activities that target small-scale awareness raising, local infrastructure improvements (lighting, bike routes, e-charging stations), and municipal building retrofits. To go beyond the norm, has meant long waiting periods, and a prevailing sense of uncertainty, consequently resulting in a degree of wariness to carry out any future changes by the municipality.

The municipality of Balzers fully understands their right to *municipal* autonomy, and as indicated in the municipal workshop, sees potential in extending this concept to *energy* autonomy in its energy strategy. However, it also recognises that such an 'extension' can only be terms of a conceptual vision or communications strategy in the short term, since municipal autonomy will still be usurped by centralised demands.

Recognising Energy City as a step towards energy autonomy

The Energy City audits and scores reported by Lenum AG as energy consultant to the council provides impetus for the municipality 'to do better'. However this incentive for gradual improvement is not sufficient for pursuing energy autonomy because the vision also requires a shift in political attitudes, planning behaviour and priorities, rather than the central focus on achieving better ratings. One could argue that the Energy City process has inadvertently skewed attention, or has given a false sense of security, instilling the feeling that while the process is in place, the work is done. There is also no scope for allowing local governments to treat the 2000-Watt target as an interim step towards energy autonomy. At the national level, EU-level and Swiss-guided targets set the basis of national level targets but these similarly do not provide scope for envisioning more ambitious energy goals like energy autonomy. The emphasis on *individual* local government work before participatory action by Energy City instills a type of competition between municipalities that prevents them to seek out each other for collaborative work or indeed to share experiences and information. As shown, municipal energy maps and plans are presently kept confidential.

The recognition that Energy City is just one step towards the target is gradually taking place, although the municipal workshop revealed that most officials have not yet established this inevitable link. There is scope to highlight this potential in further reports to, and engagement with, the local council. By extending the Energy City framework to include the years required to reach the long-term 100% target, existing problems in the framework can be progressively addressed over time, enabling more weight for example be given to collaborative work, necessary for the pursuit of energy autonomy. There is a hint that an extension of timeframes is possible given that the latest 2000-Watt energy concept for Balzers (Lenum, 2013) has added another 10 years to the previous energy concept of 2009 (Balzers Municipality, 2009).

Matching or augmenting national level incentives

Augmenting national subsidies to encourage greater implementation in energy efficiency and renewable energy is already a measure by Balzers. However, incentives in form of models to engage local businesses and industries are still needed, and since local government does not have the capacity to create its own engagement framework, national support is essential to their development and implementation.

Setting up new or strengthening existing local partnerships

A weakness in two successive Energy City audits, there is a sense of uncertainty, as shown in the workshop, of how to initiate or maintain local partnerships on cooperative energy projects. Meanwhile, collaborative work with neighbouring municipalities within the country or within the region has engendered an even greater sense of hesitation. A lot of work has been done in the area of windpower for Balzers by the Solar Cooperative and their scientific partners, and tremendous potential exist in continuing this partnership with the Cooperative to finally implement local wind turbines. However concerns and activities of the LKW has impeded progress, due to the demands for new studies and the cessation of central funding. Despite this, there is still scope for further discussion with the Solar Cooperative to continue collaborative work in renewable energy, while also strengthening engagement with the local Citizen's Cooperative (Burgergenosseschaft). The workshop participants showed great support for a community Energy Table (Energietisch), which incorporates not just the local energy commission, but also other municipal departments, related to energy such as the environment and economic commission, the Citizen's Cooperative, Lenum AG, alongside representatives from the utilities, businesses, industry, and community. This coming together of different sectors of the local society as a never-before-attempted venture was a proposal that the local government was interestingly willing to entertain. Such motivation shows great promise in establishing the necessary partnerships and commitment towards energy autonomy since the vision requires the engagement of all, not just the municipal administration.

The matching of interests in the workshop revealed that the recommendation to increase the number of projects with the Liechtenstein Solar Cooperative (Solargenossenschaft) and other community groups is possible. There is great potential for the municipality of Balzers to initiate more projects, particularly landmark/lighthouse projects with local community and regional interest groups. The Solar Cooperative is the first most obvious partner that can help operationalise actual projects since the municipality has a financial share in the cooperative.

Engaging with national government bodies responsible for energy

The willingness to engage with the national government is palpable in the local government workshop. However it was indicated that existing contacts have not generally engendered a positive feeling when it came to envisioning future energy scenarios for the country. A sense of positivity by the national government is critical, according to the local policymakers if they want all sectors of society to participate. The inability of the local government to collaborate with the national utilities beyond establishing supply contracts creates a sense of resignation that little can be done by local authorities to manage their own energy supplies. Unless changes in legislation dictate that LKW and LGV are obliged to engage in more participatory projects, particularly to carry out landmark projects with local communities, the municipality of Balzers will continue to face legal hurdles to implement local projects such as wind or hydropower.

It must be noted that the inability to be involved in the development of national energy strategies or the national energy supply network does not provide incentivised conditions for local governments in Liechtenstein to further pursue the measures recommended by the national government. The large influence of the national energy providers on local energy projects has also created a certain level of discontent and distrust amongst the municipalities, since the utilities appear to have (or give the perception that they have) the monopoly on projects, and therefore on profits. There was a concern by a few of the officials in the municipal workshop that pursuing energy autonomy could also potentially increase the grip of the providers since they are already responsible for the entire supply network, and supply contracts with them are placed by default. Their opinions also have great weight, impacting on what can and cannot be built in individual localities. The ability for local governments to become more involved will therefore hinge on the national government's willingness to create new binding *engagement* frameworks, and to amend existing laws to allow at the very least municipal feedback, or voting-rights in the decision-making by the national energy providers.

Chapter 7. Conclusions

7.1 Introduction

This dissertation set out to explore how governments can achieve local energy autonomy through governing urban development, and how an energy autonomy framework for local governments can be used to assess existing capacities towards achieving this goal. The research has sought to clarify whether existing methods in local energy planning are sufficient, or whether new tools, methods of practice, or organisational strategies are necessary to successfully pursue the energy transition. Because the study of energy autonomy is complex and inherently multidisciplinary, and the general theoretical literature on this subject with reference to local governments is limited and inconclusive, this dissertation employed a mixed-method approach to ascertain the range of relevant factors when discussing the governance of urban development for local energy autonomy. First, peer-reviewed literature was reviewed to understand the state of research into local governance with regard to energy autonomy. Second, surveys were carried out to gain expert perception on this topic, and to test and improve the framework for 100% renewable towns and cities developed by Droege et al. (2010). Third, the new framework was applied in the analysis of three 100% municipalities to determine how expert opinion matched with actions on the ground. Forth, a second revised framework was used to assess the Principality of Liechtenstein and to identify recommendations for local government. Finally, these recommendations were tested on the municipality of Balzers in Liechtenstein to assess whether they can be practically actualised. The last two steps involved three decision-makers workshops.

7.2 Main contributions of the research

This work contributes to existing knowledge on energy autonomy by providing insights into the roles local governments can play, and the context of national legislation to pursue energy autonomy as an extension to existing local energy planning practices: in this case, the Energy City framework. This research serves as a base for future studies into not only local government practice, methods and tools, but also as a means to understand how local government knowledge of energy issues and of energy autonomy can be improved. The study was framed not merely in terms of pursuing an energy self-sufficiency target, but to consider it as a way of thought and practice. Indeed, this is the first study that seeks out opinions from experts in architecture, urban planning, energy and governance, with regards to the pursuit of energy autonomy, and to compare these with actual actions on-the-ground via three energy autonomous communities. The final assessment framework, developed to assess the energy autonomy capacity of local governments, was reviewed and revised twice based on expert input and case analyses. The framework evolved to create a method of assessment that reflected actual actions on the ground and that prioritised factors. It is a framework that may be applied to other local governments elsewhere around the world. The research has also been critical in employing decision-makers workshops in determining the real issues surrounding energy autonomy.

The outcome of the research has since triggered the development of a national information session and workshop aimed at the wider community and especially local governments in Liechtenstein, to connect to the Renewable Liechtenstein Study, and pursue the goal of energy autonomy as a collaborative effort.

7.3 Main empirical findings

The principal question of the dissertation was: **How can urban development be governed to achieve local energy autonomy?**

This question can now be addressed through the summaries and discussions to the five subsidiary questions from the five respective chapters of the dissertation.

> *Research Question 1. As background to this study, what is the state of research into governing urban development with regards to local energy autonomy?*
>
> *Research Question 2. In relation to implementation, what issues should be most critically considered with respects to governing urban development for local energy autonomy?*
>
> *Research Question 3. In addressing the role of local government, what are the most significant urban development methods employed by authorities who have already achieved energy autonomy?*
>
> *Research Question 4. With particular focus on building and urban planning, how can local governments effect the transformation of existing policies and frameworks in order to pursue energy autonomy?*
>
> *Research Question 5. How can the recommendations for energy autonomy in Liechtenstein be implemented within the context of actual local government capabilities?*

In answering the five research questions, it was found that the governance of urban development to achieve local energy autonomy can be addressed in terms of three major themes. Approaches by local government to pursue energy autonomy were centred on **a) methods of improving their own performance, b) methods of targeting the wider community, and c) methods of revising municipal rules with regard to urban development**.

These three areas were characteristic throughout the entire study and functioned in such a way that it minimised internal change in government and in so doing **avoided disturbing the existing organisational base** required to achieve energy autonomy.

Within the administration, it was found that to pursue energy autonomy required a certain fearlessness to envision, to lead and then to partner; a strong awareness that benefits and incentives would outweigh the extra work; a willingness reconceive one's own responsibilities in the energy transition; a readiness to effect sufficient changes to existing tools, practices and organization to pursue energy autonomy; an optimism in using the success of projects as leverage for further support; and an openness to exchange experiences and work collaboratively. These **behavioural traits and complementary actions** were key.

Outside of the administration, the pursuit of energy autonomy required local governments to refocus priorities from a narrower look at municipal infrastructure, towards implementation based on scientific, business, industry and community engagement and ownership. This required raising awareness, seeking and mobilising relevant partners, creating incentives for participation, and maintaining engagement frameworks. The energy autonomy cases showed, for instance, the importance of creating an environment that essentially rendered **energy autonomy an eventuality or an inevitability**, whether through social pressure (Wildpoldsried, Samsø) or industry competition (Güssing). For the municipality of Balzers in Liechtenstein, this will be through developing the vision also as part of its **very local identity**.

With regard to urban development, the rules that govern it requires revisions in order to effect changes in perceptions since these currently do not reflect the **full energetic potentials** of buildings and wider urban planning. Restrictions and vague descriptions of 'sensitive' integration have to be replaced by illustrated examples. Local energy concepts should no longer be purely technical, but express the 100% renewable energy as a definitive energy target as well as a guiding future vision (Leitbild). The Energy City framework can be employed as the basis to pursue this target.

Overall, the research showed that **radical, structural adjustments in practices and organizations are unnecessary to pursue energy autonomy**. Although traditional modes of practice originated on the basis of assuming the continual use of fossil energy, it was found that simple revisions were sufficient to adapt these to supply systems based on wholly renewable sources. This now puts into question the previous belief that existing frameworks were not geared towards pursuing energy autonomy (Droege, 2009). This dissertation showed that the successful practice was actually to avoid undermining established frameworks and organizations. To achieve energy autonomy, based on the experience of the case communities, was to **effect small but lasting changes in order to weather changing political and social perceptions**. And by maintaining a consistency in approach, induce a normalisation of energy autonomy. The message: take initial small steps to normalise, but to be also consistent by continuing existing practice such as maintaining the energy optimisation of municipal assets to optimise, continuing the granting of subsidies for building retrofits, or progressively connecting residents to expanded district heating networks.

With the principal question in mind, each theme is explained in the following subsections, and includes discussions on the implications for the Principality of Liechtenstein, its municipalities, and especially the municipality of Balzers in terms of policy and practice. The chapter concludes with recommendations for further research, a discussion on the limitations, and lastly, final conclusions.

7.3.1 Local government actions in enhancing their own performance

Embracing the 'business' of energy autonomy as both a vision and target

The research has shown that the role of local government in the context of energy autonomy is shifting towards a business or enterprise model, as they face real challenges to fortify their local energy commission, develop their own energy agency or service company, or guide the establishment of a community energy cooperative (Chapter 5). But those who have achieved this, have done so with an overriding attitude of positivity and fearlessness (Chapter 4). This was similarly reflected in the strong optimism shown by the energy and government experts in the surveys of Chapter 3 for energy autonomy, who rated all of the suggested measures to pursue the vision, relatively high. The business of local government is shifting and the experts acknowledge this, **from managing to envisioning**, from focusing on "outputs" (in rates, roads and rubbish) to "outcomes" (in energy autonomy)(Chapter 3). The success of the new business of energy autonomy is shown in the willingness of the energy autonomous municipalities to envision an alternative future for themselves, and readiness to address energy consumption, optimise efficiencies and embrace a variety of renewable energy technologies (Chapter 4). This means treating the local energy strategy as both a guiding vision (Leitbild) and a technical target, echoing one German energy expert from the Delphi Survey that there is:

> "No need for just science".

This dissertation has shown that the assumed fears and scepticism against the concept of energy autonomy has been fairly low. Local governments have had to not so much convince themselves of their changing role but **counter prevailing assumptions by others as to what their role should really be, or remain to be**. Although the research suggests that the internal paradigm shift has either already taken place or is on its way (Chapter 4, 5 and 6), some vestiges of the traditional perception of local government role with regards to "servicing rates, roads and rubbish" still linger (Chapters 2, 3, and 5). The challenge for local governments has been to achieve a paradigm shift not so much in themselves, but in those connected to them, especially at the higher legislative level.

In Liechtenstein, general understanding and support of energy autonomy amongst national and local decision-makers in energy, building and urban planning, was found to be relatively high. However, regulatory or management aspects proved to be the real prohibitive factors for the pursuit of an alternate energy vision. In the decision-makers workshops, a few national officials doubted as to whether local governments should really concern themselves with the energy transition in the first place, since the country's energy supply was controlled by the national government through legislation and the two national energy providers in electricity and gas. However, it was revealed that local governments were in fact most willing to be involved in energy projects not previously considered by the national level to require their involvement or responsibility. For the municipalities of Liechtenstein, lobbying for their involvement in the development of national energy strategies will be essential if energy autonomy is to be pursued. For the municipality of Balzers, this 'business of energy', which they are ready to embrace, similarly requires the integration of supporting actors from a broader cross-section of society to carry out the necessary work. The support for an energy round table (Energietisch) to achieve this suggests a readiness to collectively address existing barriers to implementation, and identify more clearly the scientific-industry networks needed to actualise local energy projects.

Advancing local government knowledge to address preconceptions, develop confidence and maintain interest

The formal training of local government administration, particularly the elected officials, on energy matters is critical for the pursuit of energy autonomy (Chapters 3-6). Essential will be the **continual nurturing of awareness of the benefits and impacts of energy independence based on renewables** (Chapter 3) as evident in the case communities (Chapter 4). The chapters showed that much of the awareness raising was externally sourced, in that the theoretical and practical knowledge required for the implementation of projects was largely provided by external parties, such as energy consultants, research entities. Scientific expert advice helped municipalities to understand the economic and environmental benefits of pursuing the energy transition. Technical expertise eased construction, operation, generation and monitoring of energy facilities, and helped administrations to manage and monitor their own local energy systems. With such input and feedback, it helped local governments to develop a more positive outlook. It helped **to focus on long-term priorities rather than simply doing better than the previous year**. It also helped to **develop confidence** and interest in tackling the dominance of local energy utilities and competition with other municipalities. For the cases, it critically helped generate the crucial turning point: the realisation that local renewable energy production can help counter local unemployment, migration, a weak economy and degrading infrastructure. For them, these far outweighed issues of climate change or even 'Peak Oil'. The mayor of Güssing for example highlighted the feeling of stability in the municipality by being part of the local energy strategy:

> "People here feel less vulnerable because they know their energy's coming from renewable sources and not imports... This should be the top priority of anyone who goes into politics, anywhere in the world." (Tirone, 2007)

For the municipalities in Liechtenstein, the employment of energy consultants by the municipalities should continue but advice should also be sought from other parties to determine other social, economic and environmental benefits in order to develop an 'armory' of resources to initiate, reinforce or expand implementation. More critically, the strengthening of know-how and skills is essential. Better-informed local government officials can make more informed decisions and weather any expected and unexpected criticism. Apathy and weariness can be addressed through information sessions and exchanges in order to avoid the view that once the Energy City audit is completed, the work is done, and to recognise that Energy City is actually a step towards energy autonomy. Information overload can be targeted by prioritising goals with the help of the municipality's Energy City advisor. In Balzers, the consolidation of all available information on energy at its disposal and the greater involvement of municipal and community actors, even those indirectly related, via an Energy Table (Energietisch) should help prompt greater accountability and impetus to act. The willingness shown in the decision-makers workshop for more exchanges between municipalities counters the prevailing regional attitude to avoid competition.

Exploiting existing powers and legislation

The implementation of energy projects was more likely to take place if the municipalities already possessed good political discretion from the outset, and if local government representation was maintained in management boards of energy projects (Chapter 4). The cases showed however that the rules governing what can and cannot be done as a municipal task had to be clearly understood. These were usually already defined in national constitution, energy legislation or local government ordinances. However, pertinent rules that at least permit **the development of projects for the betterment of the community** – a cue for local energy projects – should be sought.

Taking advantage of any existing national or regional guidelines for governing energy efficiency and renewable energy was essential (Chapter 3 and 4), as these, combined with incentives, became the most significant methods to achieving energy autonomy. But **regional and international support should not be underestimated**. The cases showed that regional policies on energy and the environment often provided a better base for the municipalities to build upon previous projects in order to carry out more innovative activities (Chapter 4) compared to national assistance.

For the municipalities of Liechtenstein, the level of discretion was not as great as they perceived it to be, despite national laws and a constitution that assured municipal autonomy (Chapter 6). National laws for instance did not oblige the national energy providers to include the municipalities in their decision-making, even though their acceptance was crucial to the installation of any new renewable energy systems or networks, particularly the large-scale installations. At present, the municipalities can only exercise their rights by providing formal reactions to proposals by the utilities and the national government. They have no rights to veto. Unless changes to legislation dictate the obligatory engagement with local governments, the municipalities can only pursue the current practice of providing feedback but perhaps with more consistency and vigour. Energy autonomy relies on municipalities to become more engaged and 'pro-active'. Indeed, there is no stipulated restriction on approaching the national government or requesting further participation, no law limiting feedback, and no Act hindering the request of technical or organizational assistance in the development of local energy projects (Chapter 5).

But despite the limited rules of engagement, legislation for most municipalities was found to be less a hindrance than their attitude towards maintaining the regional status quo and to avoid competition between local governments. Future interaction will be key asserted one Australian planning expert:

> "Put simply if institutions do not rethink how they act, operate and interact with their peers and stakeholders then major barriers to change will be encountered. Theirs is a fundamental need to rethink contracts and responsibilities between the different parties to ensure that any conflicting agendas are neutralized and disincentives for change are addressed."

In Liechtenstein, if and when local governments do decide to pursue the goal of energy autonomy, they can at the very least begin exploiting their political autonomy as enshrined in the State Constitution. They can manage their own assets, local planning, water supply, sewage and waste disposal (GemG, 1996) and the right to pilot projects, revise structure plans, zoning plans and target-oriented implementation (BauG, 2008). The first law gives them scope to develop their own energy assets as well as those with and for the community; the second law upholds the right to implement landmark projects. For the municipality of Balzers, landmark projects (Leuchtturmprojekt) were enthusiastically supported. The provision for local planning gives them scope to go beyond the action-based-on-retrospection method of the Energy City framework. They can aim at local businesses and industry directly by creating their own or matching national level incentives. They can create targeted information sessions for the public regarding energy efficiency and renewable energy. They can seek other local government and regional partners to collaborate on concrete projects. Such activities are consistent with the provisions of municipal autonomy.

Identifying energy leaders and fortifying responsibilities

The findings affirmed that leadership, in particular mayoral presence on local energy commissions was essential especially in the early initiating stages (Chapter 4 and 5). It was found that at least two individuals were essential to realising energy autonomy: one person, usually the mayor, to be responsible for legal and policy decisions, and another to manage the technical side of implementation. In all case narratives, these two individuals were always present. Often a third person was needed to mediate directly with the local community. Unlike the traditional practice of embedding energy-related matters within the building and infrastructure departments, the individuals who were responsible for coordinating the construction and operation of energy projects, and managed the engagement process with the community, were nearly always positioned separately to the existing departments (Chapter 4). It was important that at least two of the figures were from the local area, were recognisable members of the community, and possessed academic and practical experience in energy and environmental matters. The individuals were given clear areas of responsibility and executive powers, confiming the belief of one Australian government expert that:

> “Without a clear locus of responsibility within the organisation and the ability for that responsible person to 'do whatever it takes' to pursue the outcome of renewable energy, the many ways of achieving that outcome will not be realised.”

As for the local energy commissions, these played a more executive role that was tied to the mayor’s office and coordinated all relevant departments to pursue the local energy concept. As the central steering group, the local energy commission would manage implementation by directing the project themselves or directing others in the ownership and operation of energy projects (Chapter 4). As the case of Samsø, the energy commission also developed special frameworks in order to form community energy cooperatives.

Although most experts in Chapter 3 considered structural changes necessary to achieve energy autonomy, the cases showed that this was not critical (Chapter 4). If structural changes to local government mean altering the flow of authority, information, and responsibility in the organization, the cases showed that these **flows have been strengthened rather than altered**.

In Liechtenstein, the pursuit of energy autonomy will require the nurturing of existing leaders and nomination of future leaders that share the same vision (Chapter 5), possibly via the monthly mayors conference (Vorsteheherkonferenz). For the municipalities, there is scope to create protocols to maintain focus on energy issues during municipal meetings and not to rely on spontaneous signals or a few motivated individuals or “lone figures” to remind or maintain interest. There is scope to maintain existing energy advice from external energy consultants for expert monitoring and install at least one in-house full-time staff member dedicated to local energy to coordinate individual departments actions in pursuit of energy autonomy (Chapter 6). However, fluctuating budgets and priorities remain critical factors to contend with. With regard to Balzers, two of the three potential leaders for local energy autonomy can be identified: its mayor is already considering advice as to how the municipality can achieve energy autonomy (as provided by the author of this dissertation), and the current head of the municipal energy commission has the necessary qualities to lobby community support. However, there is no existing councillor or administrator at present, who can assume the role of lead technical coordinator. Although the current figure responsible for building and infrastructure may undertake this role, this may result in an overload of tasks for this individual. The linking of the local energy commission to the executive council (Gemeinderat) is already taking place since the head of the energy commission is also a member of the executive council (Chapter 6). Further discussions will be essential to determine the correct three individuals to implement the vision.

Translating knowledge into concrete action

Knowledge does not necessarily translate into action. According to the research, the real concern for local governments was **knowing whether they can act upon their knowledge, knowing how to act, and knowing who to turn to for assistance and what form of assistance was available**. It was not a question of tools to achieve the target but **understanding the process** needed to pursue it (Chapter 4). This is consistent with the assertion by one Australian government expert that the lack of formal recognition of municipal responsibility in energy merely compounds the apathy towards acting on available information on energy:

> "…energy is not considered the business of local government administration which means that most local bureaucracies lack the fundamental skill base to even know what to do if good information or modelling were available."

To achieve energy autonomy, the cases demonstrated that the process involved interpreting the potentials (knowledge), identifying the technologies, evaluating their cost-effectiveness, understanding who would construct, own, operate and manage the facilities, and what regulatory conditions may impact implementation. The municipalities had to not only make sense of the large pool of information (plans, reports, and models) on energy and to consider it with respect to their community context – which meant consolidation, interpretation and further discussion – but also knowing the steps to take in order to implement the right project. Critical was also the awareness of the available legal and financial support available to operationalise projects and activities, and from which levels of government (e.g. national, regional or EU). For the cases, it was the international and regional governments, rather than the national government, which were the main contributors to the larger-scale renewable energy projects, essential to finally achieving the 100% target (Chapter 4).

In Liechtenstein, the Renewable Liechtenstein study, which employed local energy potentials modelling to visualise energy autonomy scenarios has not prompted any additional actions by municipalities since its release (Chapter 5). For the municipalities, they have steadfastly adhered to the Energy City framework for guidance and for prompting activity. The preference has been to maintain a consistency in efforts according to a set regime. For the municipalities, there is no dearth of data or information. But because the Energy City framework does not articulate any other targets besides the 2000-Watt goal, there has been no incentive to pursue 100% self-sufficiency for either the local or national governments. However, opportunities still exist to innovate and embrace alternatives by the municipalities. There is scope to exploit existing rules regarding municipal autonomy by making use of the Energy City framework as a basis to pursue energy autonomy. For the municipality of Balzers, its mayor plays an important role in initiating this turn towards more ambitious targets. Studies and advice from the municipal energy consultant and other external experts suggest that based on the current rate of implementation in Balzers as guided by its Energy City guidelines, and on the extension of existing projections to 100%, energy autonomy can in fact be pursued, but this requires more detailed understanding of the stakeholder ownership structures needed to implement the various energy projects – the stage in the process which is currently missing.

Using achievements to lever support for further projects

Energy activities that normalises energy autonomy requires consistent support over a period of time. Tools and participatory actions are lobbying measures that local government can employ to lever the support required in financial, legal and technical terms to initiate implementation (Chapter 3 and 4). For example, modifying existing land-use codes or supplement existing codes, matching or augmenting national subsidies for energy efficiency and renewable energy projects, promoting success of local energy activities, participating in national level decision-making on energy, setting up new partnerships with businesses and industry, extending existing partnerships with local associations, improving knowledge on energy matters, or taking advantage of their right to municipal autonomy, which also extends to energy autonomy. The recycling of energy savings and profits from local energy projects into new projects through a revolving energy fund can also help maintain this momentum towards energy autonomy (Chapter 4). One Danish energy expert notes the critical presence of **long-standing legislation and incentives on energy**:

> "With long and well known incentives from the government all parties know the economy of the investment in renewable energy and will be able to plan for this."

For the municipalities of Liechtenstein, all local governments are consistently improving on efforts. This consistency in efforts however needs to be capitalised upon by setting higher targets and embracing more innovative measures. Chapter 5 showed that each municipality have constantly achieved milestones in implementation, from developing local energy cadastres to constructing district heating networks for municipal facilities. There is still potential to use these milestones as the basis for developing proposals to implement more advanced energy projects, either as a collaborative effort with neighbouring municipalities, with businesses, industry or the general community. When the decision-makers workshops affirmed the hypothesises that there was a lack of trust placed in local governments to implement measures (Chapter 5), it showed that the recognition and trust from the national level could only be achieved through the success and promotion of local projects. As the first municipality to include a zone for local energy production in its municipal zoning plan, Balzers set an important precedent not only for other municipalities to follow, but to also prompt itself to improve and adapt its building and planning codes further, for example, to integrate the information provided by its Energy City consultant and analyses provided by the Liechtenstein Solar Cooperative.

Allowing the local government organization to grow

The case communities showed that local governments often resorted to creating separate energy development entities in order to implement projects (Chapter 4). However, the control over these external entities was preserved by maintaining representation on the management boards. The **separation is in terms of the coordination of operations but not of accountability**. The cases showed that an improved municipal energy commission, as described in the previous section, can remain part of the existing local government structure, but it can also evolve into an association that is partially disconnected from but maintains accountability to the administration (Chapter 4). Alternatively, the former (usually smaller) energy commission can exist in parallel with a larger operating 'offshoot' (e.g. community energy cooperatives or municipal energy company). These organisational options therefore allowed for the local government structures to remain largely untouched. This finding dismisses the fear shown by experts in Chapter 3 that separating entities would just mean the creation of more silos, even though some experts conceded that separation might be needed if existing bodies were found to be incapable of pursuing the necessary activities, as noted by one German government expert:

> "It is necessary to analyse the local structure first (maybe existing actors are able to fulfil this function). This question needs elaboration whether existing organisations are

> appropriate, a new entity is necessary or - maybe only for a first phase - an intermediate organisation can help promote the topic."

For the municipalities of Liechtenstein, available budgets and national legislation dictate what measures are permissible for local government and the extent to their capacities. However by supplementing existing capacities through collaborative work, this could fill the gaps in discretion. There is scope for example, in Balzers, to establish a community energy cooperative with the involvement of the local Citizen's Cooperative and the Solar Cooperative to finally implement windpower in the municipality. The elements, groups and people are there to pursue energy autonomy, an entity that would take the responsibility for local energy supplies coordination such as an energy round table (Energietisch), is missing.

7.3.2 Local government actions in targeting the broader community

Establishing a stakeholder engagement model

The research revealed that **neither a strict top-down or bottom-up model was prerequisite for energy autonomy**. Wildpoldsried was found to be both a top-down and bottom-up model, Güssing was essentially a top-down model, while Samsø began as a top-down energy model triggered by the participation in the national Renewable Energy Island Competition, but relied on a bottom-up process of community participation in order to carry out project implementation (Chapter 4). Initial citizen acceptance in all communities was already relatively high but this still had to be maintained through community involvement in various capacities, and at different stages - as the receiver of information, participant in citizen discussions, shareholder in the local energy system, or operator of an energy plant. In Samsø, leaving the implementation of the energy concept to the community worked to overcome resistance and limited municipal budgets. However in Güssing, the voluntary participation in the district heating network was the only direct means of community engagement as citizens were able to benefit from all of the locally generated energy without much personal effort (Chapter 4). According to Søren Hermansen, director of the Samsø Energy Academy:

> "One of the keys is that we didn't leave anybody out." (Alden, 2007)

For the municipalities of Liechtenstein, the top-down model in energy planning has largely prevailed. Engagement with different energy-related parties was limited to local governments' relationship with the national energy commission (Energiekommission), the energy office (Energiefachstelle) and to some extent, the national utilities (LKW and LGV) through supply contracts. The municipalities also work with the community but merely to give advice on energy matters through its building office. In general, cooperative work on implementing common energy projects was rare. This is evidence of the limitations of an over-reliance on regulatory parties to impact implementation. A stakeholder engagement model is essential in Liechtenstein if energy autonomy is to be pursued, such as the one employed in Samsø, whereby all the relevant local parties (economic, business, industry and community) were gathered to develop a local energy plan whereby the target was defined, the energy statistics were evaluated, the technologies were identified, and the responsibilities properly delegated or shared. Whether it be top-down or bottom-up, it was up to the collective to decide. Existing local energy strategies, such as the one developed for Balzers, must similarly undergo this step of local stakeholder feedback because the existing local plan focuses most particularly on municipal work rather than on stakeholder cooperation, a prerequisite for energy autonomy.

Establishing new partnerships and bolstering existing ones

The energy autonomy cases in Chapter 4 showed the importance of networking responsibility, where local champions in governance (micro) and independent community actors (macro) worked in collaboration or in parallel. The individual, usually the mayor, provided the promotional and regulatory ‘face’ to the local energy concept. The collective provided the technical web of shared responsibility, profitability and accountability. In all cases each partner had a critical role to play, affirming the view of one Swiss planning expert that:

> “Partnering brings people with different points of view together to solve the strategic challenges. Community action can push politicians to act, industry alliances can result in synergies.”

The research showed that implementation was best achieved by **inducing a dynamic form of cooperation between the four key players in the areas of government, science, industry and community**, and not on a static form of in-house regulatory rule. The research revealed that the communities who achieved energy autonomy also strengthened existing collaborations through pursuing further energy activities and projects. It would begin with simple energy consulting on technologies and financial incentives, or statistical evaluations on municipal energy or the monitoring of the energy performance of local buildings, and would then progress to thermographic analyses, energy modelling and accreditation reporting (e.g. European Energy Award®). Furthermore, **existing trust and established collaborative practices were capitalised upon**. If existing partners did not exist, local governments sought out potential partners for help, in particular for the operationalisation of specific landmark or demonstration projects. Their responsibilities in time also evolved to provide data that informed local policy or to serve as advisors or constructors of projects.

Because energy autonomy ultimately required also large-scale intervention in the form of windpower, biomass cogeneration and district heating for heating and electricity, that were then supported by medium (small hydro, individual biomass) systems, and supplemented by small-scale technologies (photovoltaics, heat pumps), the type of renewable energy system also required the identification, mobilisation and grouping of the right combinations of actors. **The likelihood of implementation of technologies or systems of a certain scale often correlated with the size of the organization/s behind them**. Research and development networks or public-private partnerships were found to work best for large-scale energy generation, community cooperatives for medium-sized projects, and individual households for small-scale installations. Because a mix of installations was often essential, groups responsible for different energy projects were rarely mutually exclusive, in that the same individuals could also be found in the management teams of other projects. The real challenge for the local government has therefore been the need to **coordinate the right actors while determining their ownership and operation preference** (Chapter 4). Organizations now have to adapt to the energy technology in question, affirming the words of one German energy expert for:

> “new governance structures for a decentralised energy supply system”.

In Liechtenstein, municipal competition has been consciously avoided to maintain regional harmony, but equally avoided is intermunicipal collaboration required to pursuing the energy networks essential for achieving energy autonomy. There is very low impetus to counter this impediment, even though one cooperative association (Liechtenstein Solar Cooperative) in the country already exist and show great potential in really driving implementation, since most parties – national, local and private – have a stake in the association. It is essential that the freedom to innovate not be stifled by the overriding concern to keep the status quo (Chapter 6). It is important that the established scientific-industry networks are fully taken advantage of, such as collaborations with the Liechtenstein Association for Engineers and Architects (LIA) to promote best industry practices in renewable energy technology, particularly in encouraging architectural practice that advocates energy autonomous concepts; cooperation with the Liechtenstein Solar Cooperative (Solargenossenschaft) to finally implement local windpower on the back of several windpower studies conducted in previous years; the Wastewater Association of Liechtenstein Municipalities (AZW) and Liechtenstein Gas Supply Company (LGV) to study the use of waste heat from local industries; and even the Liechtenstein Power Company (LKW) to guide pilots or landmark projects for deep geothermal and hydropower on the Rhine River, as well as continue the optimisation photovoltaic installations on roofs throughout the Principality. New partners can be embraced but is not essential from the first instance. Since all of the municipalities expressed interest in participating in some capacity in the country's energy transition (Chapter 5), there is huge potential to capitalise on this attention in order to induce implementation by all, not just those in power.

For Balzers, collaboration with its local Citizen's Cooperative (Bürgergenossenschaft) on energy projects has been underdeveloped and requires new strategies to include its participation. Other local groups in Balzers exist (energy commission, environmental commission and economic commission, and groups indirectly related to energy) but it was a revealed that they too have been rarely included in *formal* municipal discussions on energy. An Energy Table (Energietisch) that creates an inclusive working environment for organising the partnerships necessary may provide the answer to drive implementation towards energy autonomy. This serves to also capitalise on already emphatic support for more information sessions and experience exchanges by the municipal officials (Chapter 7). Collaborative projects with neighbouring Triesen, the municipality with the best Energy City score in the country for example, can help set an important participatory precedent that can generate a type of peer pressure, which compels the rest of the municipalities in Liechtenstein to rethink their own goals and to collaborate with their closest neighbours. The shared work on concrete projects would also mean the sharing of information that is presently closeted – in particular the energy structure and cadastre plans of individual municipalities (Chapter 6).

Freeing the local energy knowledge network to induce implementation

The cases in Chapter 4 showed that an active knowledge network with scientific, business and industry partners assisted in the initiation, construction, operation and maintenance of local energy projects, particularly in larger scale works such as biomass heating plants, district heating and windpower. The scientific and industry networks was found to accelerate development, help innovate new ideas on local renewable energy, monitor operations, and provide valuable feedback to inform policy reforms. **Conversations with each other and others not in local government were paramount in order to learn and convince** (Chapter 4). Although the Chapter 3 surveys revealed that cultivating knowledge was still undervalued as shown in the preference of budgeting for local energy projects over information campaigns by experts, the cases in Chapter 4 showed that the real emphasis was rather on stimulating research and development by external parties to supplement local government decision-making, and to disseminate up-to-date information widely to the general public. Energy autonomy means **easing the flow of information and being transparent**, as asserted by Wildpoldried's mayor Arno Zengerle:

> "From the beginning, I did everything publicly." (Hanns Seidel Stiftung, undated)

Placing municipal targets, potentials and other salient energy data in the public domain was essential in order for the local government to prioritise concerns and moreover establish new or form stronger partnerships by matching or aligning interests of community actors (Chapter 4). The cases also confirmed the experts' opinion that **awareness raising did not mean passive dissemination of information but the structured teaching of energy-related issues by experts tailored to different actors** through such means as seminars, workshops or information days. In each energy autonomous community, the quality of the information was maintained since scientific and industry partners were in place to provide credible data and regular updates (Chapter 4). Voluntary community action was induced by the continual provisional promotion of incentives to residents, businesses and industry, with regards to building renovations, small-scale renewable energy system installations, or connections to new local district heating systems. It therefore gave local consumers a choice of a number of energetic options.

The municipalities of Liechtenstein have access to a fairly large pool of information developed in recent years by the national government of Liechtenstein, the University of Liechtenstein, local energy company Lenum AG and other entities. They have used these to inform the development of individual local energy concepts, action plans and energy structure maps. They have also used these to commission studies for special local projects, for example, the capture of industrial waste heat from the local industrial plant, or a local woodfire heating plant. However unlike national energy statistics and policies, it was found that individual municipal energy data was largely proprietary, for the eyes of the administration only. The pursuit of energy autonomy requires an informed, active society that understands the energy potentials of their home or workplace. Therefore the placement of energy-related information in the public domain in the long-term is critical.

For the municipality of Balzers, most energy data also remains within the confines of municipal decision-making. Designated experts and councillors are the only parties to the information. The realisation that community involvement in the municipal energy planning process, which takes into account local knowledge of issues and capabilities, is however arising. When the local community cooperative (Bürgergenossenschaft) and energy commission (Energiekommission) were included in the municipal workshop, it was found that despite the different perspectives on the local energy strategy, specific activities which each had shown interest in were found to match. This means that potential partners do exist that can pursue specific actions. In Balzers, wider community access to, and feedback on local plans and concepts will therefore be essential if the municipality wishes to pursue energy autonomy in the long-run, since every action at whatever scale can contribute towards the energy transition (Chapter 4 and 6).

7.3.3 Local governments actions in the urban development and building process

Based on the research, governing urban development for energy autonomy requires *normalising* the vision by carrying out energy projects however small or large in a consistent, methodical manner, so they naturally become part of the social, political and environmental landscape and by improving or adapting existing practices and organisational means to ensure that activities do not jar with accepted traditions that would cause to alienate people.

Energy City for energy autonomy

The research showed that the Energy City framework could be employed as a basis to pursue energy autonomy (Chapter 5). The hypothesis in Chapter 1 that the current framework is not an effective tool for motiving local governments in Liechtenstein to pursue energy autonomy was unfounded as it was revealed in the research, that it could actually **provide the necessary intermediary steps for the pursuit of energy autonomy in the long-term** since the targets and measures were actually consistent with the Renewable Liechtenstein targets and measures (Chapter 5 and 6). This does not mean downplaying the significance of Energy City, or working against or discarding it, but using it as the base to advance actions. It should not - as feared by one Swiss planning expert - "assume a negative status of [incumbent] energy programs". Wildpoldsried's mayor Arno Zengerle affirms the adaptation of established frameworks and simply states:

> "Begin with small measures and take them successfully to an end. Then act as a model with your own buildings, with respect to energy efficiency and production of renewable energy. Set up an energy team and as time goes by it will be taken for granted" (CIPRA, 2010b).

For the municipalities of Liechtenstein, the recognition to advance Energy City as a basis for energy autonomy would require strong ideological and political support from the national government. This is similarly the case for the municipality of Balzers. The research showed that there is a steady realisation by the municipality that the optimisation and maximisation of programs reported to Energy City can actually help them achieve more ambitious energy targets, since recently revised targets now reach as far as the year 2100, whereby 2000-Watts and 75% share of renewable energy consumption have been predicted (Lenum, 2013). Therefore, there is no reason why the time-scale should not also be extended until the time when the 100% share is reached. However, whether such a target will be condoned by the national government will require further debate and deliberation.

Cultivating the energy autonomy vision as part of the local identity

To have a local history rooted in the tradition of community cooperation, self-help and resource self-sufficiency has helped to achieve the mobilisation of actors needed for the pursuit of an energy autonomy strategy as shown by the energy autonomy cases (Chapter 4). As energy autonomy is a long-term vision, by **tapping into the identity of the place that is based on the same kind of independence** and positioning the vision as a communications strategy, the target can be sustained in the face of short-term political cycles, changing economies, and evolving energy technologies. The director of the Samsø Energy Academy, Sören Hermansen describes how Samsø's 100% strategy connected to established regional traditions:

> "This is an old, traditional model of cooperative organization. We modernised it and used it once again." (Beermann, 2009, p. 52)

Although the municipalities of Liechtenstein are no longer the agricultural communities of old, the prevalent and enduring rural identity or character of the region can be used as a basis for realising the energy autonomy vision. In Balzers, local movements are still actively working towards preserving local cultural traditions (Vogt, 2007). By adopting the energy autonomy vision as a cultural aim in the revised local energy concept, the preservation of such independent rural traditions can be reinforced.

Adapting the local energy concept

The cases showed the importance of adapting existing local strategies to incorporate more ambitious energy targets, collaborative projects and 'roundtables' that also worked to **address local issues** such as municipal debt, unemployment, poor infrastructure, stagnating economy, underutilised resources or environmental degradation. (Chapter 4). Local energy concepts, which achieved energy autonomy stipulated definitive energy targets such as *100% energy independence* or *self-sufficiency*. In doing so, the local energy concepts **provided a direct and demonstrable energy production target, which was difficult to oppose**. Indeed, the target placement became a strong determinant to actually attaining the goal. This was also consistent with the tendency in the literature review and case narratives to use *100%*, *self-sufficiency* or *energy independence*, over the term *energy autonomy* (Chapter 2 and 4).

The research results lead to the suggestion that local energy strategies should at least be *geared towards energy autonomy*. This means incorporating analyses, optimum targets and strategies implemented via a stakeholders engagement framework, even if self-sufficiency is not an overriding priority in the first instance. The local energy concepts of the three cases were for example energy-autonomy-ready, in that, as the technologies improved and economies changed, the municipalities were able to adapt and continue implementation accordingly. The cases also showed that local energy concept were not treated as a purely technical vision but also served as guiding vision (Leitbild), which incorporated the aspirations of the local government and the community (Chapter 4). Visions like energy autonomy, according to one planning expert from the United Kingdom:

> "…are really abstractions of reality, which require a range of assumptions and selections to be made, which is in itself inherently political. When using such representations for decision-making purposes it is important to be aware and actively think of their political/symbolic/discursive significance at every stage of the process."

In Liechtenstein, local energy concepts already stipulate energy principles, targets and measures, with some incorporating community mission statements that aim to use the energy concept to address local aspirations. Due to the differences in the availability of resources, geographic size and political willingness, the scale of ambition shown in the concepts have varied: Balzers has projected targets as far as 100 years into the future, while the municipality of Schaan seriously contemplates energy independence in its newsletters. To achieve a consistency in approach by the local governments that make up Liechtenstein requires all to at least adopt energy autonomy as a guiding vision (Leitbild). National support is critical to this effort. For the municipality of Balzers, the stipulation of far-reaching targets in their energy cadastre and open discussions on energy autonomy has made it a viable and credible proposition. 'Renewable Balzers' was even suggested by one municipal official as a motto. Meanwhile there is no dearth in local energy statistics and potentials studies. These few indicators show that great potential exists for the municipality to ready its local energy strategy for energy autonomy.

Revising building and spatial planning codes

Even though the experts surveyed in Chapter 3 deemed it the least significant method for achieving local energy autonomy relative to the other proposed measures, they still agreed that spatial planning, in contrast to building, still plays an important role. Indeed, building-related measures were generally given a higher priority. By Chapter 4, the cases showed that **spatial planning was actually essential to the organisation and prioritisation of projects**. Regional energy plans and national planning legislation stipulated where and how large-scale renewable energy installations such a windpower turbines can be implemented. The cases also confirmed expert opinion that simple adjustments to local codes were sufficient to promote energy efficiency and renewable energy measures. Existing municipal codes such as zoning plans can be easily improved by showing the preferred positioning of renewable energy technology systems and networks. The complementary building codes could similarly be adjusted to explain appropriate sizes, standards of construction, and environmental impact considerations.

Indeed, energy autonomy requires a new approach to building and urban planning but this is not as drastic as one may think, since the research showed that what was most essential was to **revise the way we perceive the function of buildings and urban infrastructure**, as shown by the comment of one planner and architect from Italy on the future role of urban planning:

> "Renewable energy autonomy in urban planning needs a new approach. Reformulate the role of energy on strategic and general practices. Organise the general plan by polarity models and of stipulated energy grids. Buildings and public space are transformed as energy power unit, interconnected with appropriate network of small and medium autonomous intelligent systems grid to energy districts."

The research shows that there is tremendous scope to adjust existing municipal codes to incorporate more ambitious rules, expressed in such a way that **encourages innovation and experimentation** (Chapter 4 and 5). For the experts in Chapter 3, to achieve energy autonomy would ideally mean replacing 'minimum' standards for building construction with an 'unlimited' approach towards achieving energy autonomy in buildings – subject of course to local conservation and environmental standards. By Chapter 4, the cases showed that the 'unlimited' approach is not essential but rather focused on **preferencing higher environmental standards in new buildings as the new minimum**. For the experts, energy autonomy also means improving land-use planning to encourage mixed-use development and organised according to the infrastructure and distances required to optimise energy efficiency and renewable energy integration. In Chapter 4, each of the cases confirmed this aspect.

Overall, the **improved codes helped raise awareness of the energy savings and potentials, assisted the setting of priorities by local government, and provided clear parameters for builders and developers**. Although the use of energy scenario maps generated from energy potentials modelling was not seen as critical according to the experts, the cases revealed that the potentials analysis, energy cadastres and energy network maps were useful to formalise the vision, visualise targets, give potential projects credibility, and attract stakeholder involvement.

In the case of Liechtenstein, there is scope for reintroducing spatial planning policies previously explored in the 1970s and 1980s but with an added dimension in linking them with new energy modelling techniques and mapping tools. Earlier ideas should be revisited to include provisions related to preferred settlement forms; building types, orientation, density and form according to energy performance; and public space and landscape design, but discussed in the context of energy efficiency and renewable energy technology integration. This would counter uncertainty as to the real impact of spatial planning to achieve energy targets as shown by the policymakers in the workshops (Chapter 5). A national spatial energy plan can help formalise energy requirements by delineating areas for energy production depending on technology, areas for future district heating networks, areas for potential energy renovation, energy storage, and areas distinguishing energy performance. These can then be reconciled with demands of existing historic conservation areas, nature protection zones, wildlife habitats and dangerous landscape zones. The improved plan would present a future vision that all stakeholders can pursue, rather than just as a record of activity. It can also serve as a guide in content and language that municipalities can follow when adapting their own energy structure plan.

In relation to buildings, there is legislative scope to make photovoltaics and solar thermal installations on buildings mandatory, since this was shown to be generally supported by most policymakers in Liechtenstein. An 'unlimited' approach may not be popular but the adoption of Minergie-P as a minimum standard for all refurbishments and new buildings should in the future be implemented. As for existing municipal codes, there is potential to take away restrictions and vague descriptions and to better account for the pool of locally relevant information created by a variety of interested parties. Although rules for renewable energy installations – though generally for solar thermal and photovoltaic installations – exist in prose for nearly every local government, design guidelines do not (Chapter 4, 5 and 6). There is huge potential for the development of an illustrative code to guide the integration of renewable energy technology, which also includes windpower, hydro and cogeneration plants. Although it was found that photovoltaic installations did not contribute to the cases achieving energy autonomy, its promotion was more as a means to normalise renewable energy technology in order to prompt further activity, and to serve as symbols of local innovation (Chapter 4).

Finally, any revised municipal building and zoning codes should be linked to the already prepared municipal energy structure and energy cadastre plans (Energierichtplan, Energiekatasterplan). These should then be collectively placed in the public domain, in order to improve public knowledge and thereby compel independent community action. It would also improve the significance of existing energy plans as more than a means to gain further points in the Energy City audits, as is occurring at present. This is pertinent for the municipality of Balzers since codes have been amended to include areas zoned for energy generation that has then been explained in its building code and guided in its installation through rules on energy recovery systems. What is presently missing are the illustrated guidelines, access to the energy structure and cadastre plans by the general public, and a community participation framework. Indeed, to achieve energy autonomy requires visual cues, freedom to information, and rigorous debate and deliberation.

7.4 Recommendations for future research

The issues surrounding energy autonomy and its implications for urban development is extensive even at the local level. To generate achievable policy strategies and development targets with regards to governance of urban development for energy autonomy, there is a need for further assessments. Exploring the following for future research can facilitate the achievement of this goal:

- National incentives to drive local government innovation.
- National energy structural plans as regulatory and design guides for local government.
- Engagement frameworks to encourage business, industry and community ownership and participation in local energy projects.
- Engagement frameworks to encourage collaboration between utilities and municipalities in the management of the local energy supply system.
- Intelligent networks and storage systems at the local government level.
- Local energy structure plan as statutory extensions to municipal codes.
- Local building and spatial planning code as an illustrated guide for the integration of renewable energy technologies.

7.5 Limitations of the research

This dissertation only examined energy autonomy in terms of the replacement of the final energy consumption in building and urban areas with renewable energy. Embodied or gray energy in the transportation, construction, operation and maintenance of the built environment was not included. Energy autonomy was taken as an annual calculation, rather than a by-the-minute or hourly target. A municipality was considered energy autonomous if it either achieved 100% self-sufficiency in electricity or heating, or both, in buildings, for a given year. Renewable energy production was not necessarily to be taken *intra-muros*, or within the limits of the local government boundary, but the renewable energy generated at or closest to the point-of-demand was prioritised over renewable energy imported from regional sources, the latter therefore not being wholly discounted. In this dissertation, mobility as one aspect of spatial planning was not examined, in part since the Renewable Liechtenstein study on which the detailed research was based did not include transportation energy in its spatially disaggregated calculations.

Within each of the chapters, a few limitations should be noted:

The literature review in Chapter 2 only examined peer-reviewed literature, which resulted in only 25 articles. There were many papers from Germany on energy autonomy and governance, but these were not peer-reviewed but existed as working papers, reports, online articles, masters papers and dissertations. In Chapter 3, the Delphi survey employed began with a relatively good sample size (n=77), however by the second and last round, the size was much smaller (n=24). The comments from the last round was, however, sufficient to provide an indication of the general trend, and therefore this round, compared to the first, evolved as a discussion rather than providing a consensus on issues. The framework of questioning also did not include questions on municipal assets since the study focused more on optimising implementation by the wider community. In Chapter 4, the three energy autonomous communities chosen may not directly complementary in size, population or renewable energy source, with the main case study of Liechtenstein. However, these were chosen based on their instructional potential with regard to building, spatial planning and logistical arrangements. Although the local governments in the cases enjoyed a relatively high standard of living and education, and therefore possessed the greatest capacity to achieve energy autonomy, this study was not so much concerned about energy autonomy as a technical target but rather energy autonomy as a process or mode of practice. Although the two decision-maker workshops in Chapter 5, which aimed to determine attitudes towards energy autonomy and possible actions, involved only a small sample of officials (n=17), this still provided sufficient information since national and municipal officials tended to share similar views, particularly in such a small country. Finally, in Chapter 6, the analysis on the municipality of Balzers relied primarily on one municipal workshop, one survey, several interviews, and an analysis of local energy statistics and strategies to test the recommendations made in the previous chapter. This was still sufficient to gauge reactions and understand concerns.

Although the results in this conclusion are considered by the author to be transferable to other towns and cities, caution must still be applied in light of the above limitations. Overall, this dissertation considers that that much of the limitations have been tackled by considering a wide range of information from different sources – surveys, case studies, interviews, email communications, workshops, and document analyses.

7.6 Conclusion

In this dissertation, the operational governance of projects has been crucial to understanding the process of achieving energy autonomy. This process is carried out by municipalities that operationalises targets through augmented organisational frameworks and the normalisation of local energy activities – and therefore of energy autonomy. Indeed, the evolution of perceptions for energy autonomy can be traced throughout the chapters of this dissertation. Chapter 2 showed that existing studies into energy autonomy regarded it primarily as a question of science, technology or engineering. Chapter 3 revealed that experts regarded it as a matter of developing regulation, incentives and partnerships, even more so than information and spatial planning. Chapter 4 raised the significance of raising awareness and planning, while also showing that knowledge, behaviours, and powers of mobilisation of those in charge of energy were even more critical. Chapter 5 showed the difficulties municipalities would face in order to pursue alternate visions of their own in the face of national legalese. Chapter 6 represented this struggle in action, potentially resolved through simple devices such as the creation of a stakeholders energy round table combined with local participatory frameworks.

This research has found that in order to understand ways to govern urban development for local energy autonomy requires more than energy potentials studies and cost-optimisation evaluations that existing literature tended to focus. Urban development, managed through building and spatial planning for example has shown to play a significant role in impacting the energy transition. It was not relegated as a tool or medium that merely conveys energy. For municipalities, the education of local government on energy matters has not been as critical as hypothesised. Instead it was the strengthening of roles and powers related to energy that was led by the mayor and it was maintaining a consistent level of awareness with the help of scientific and industry partners on the municipality's energetic progress, which were most important. This allowed appropriate decisions to be made. Major structural changes in the organization were also found to be unnecessary, as small organization changes related to the strengthening and delegation of responsibility that distinguishes between policy-making and managing local energy projects sufficed. These aspects were common to the energy autonomous communities, which affirmed also the hypothesis that common principles in pursuing local energy autonomy do exist despite differences in geographical, economic and social contexts. Although local government planning practices were originally conceived on the basis of fossil fuel use and has maintained this propensity since the Industrial Revolution, the research suggests that existing planning practices can be geared towards pursuing energy autonomy.

With regard to the case study of Liechtenstein, local building and planning frameworks were found to be consistent with traditional planning practices around the world. In Liechtenstein, these they have used to also pursue the Energy City accreditation. In fact, it was found that if these were maintained, and supplemented with more innovative practices, energy autonomy could in fact be achieved.

Furthermore, the decision-makers workshop revealed that there is ready support from both the local and national governments in Liechtenstein for energy autonomy. This falsifies the hypothesis that the governments of Liechtenstein, national and local, were sceptical of the vision and did not think they had the capacity or training on the subject. Instead, it was revealed that it had more to do with the lack of trust placed by the national governments in local governments to implement measures necessary to pursue this vision, as well as the singular control by the national energy entities that have dampened independent local government action. When the recommendations for Liechtenstein local governments were applied to the municipality of Balzers, it was found that these wholly relied on the support and confidence from the executive levels of the municipality. This affirmed the hypothesis that it did not so much concern the lack of awareness of energy autonomy or self-sufficiency but rather the degree of local discretion. The research confirmed the belief that since budgets and staff on energy were limited, the Energy City accreditation was also considered sufficient, while any alternative vision considered extraneous work. On the other hand, it also found that there was a realisation amongst municipal officials that the Energy City framework could in fact become a basis to pursue energy autonomy, with the Energy City 2000-Watt target as just one step towards this goal.

In this dissertation, the 'Urban renewable power policy toolbox' by Droege et al. (2010) developed for the World Future Council has been very helpful in appreciating the complexity of governing urban development for local energy autonomy in conceptual and methodological terms. The final energy autonomy factors as an analytical framework, developed on the basis of the toolbox finally assisted in determining the capacity for self-organisation for the pursuit of self-sufficiency or energy independence.

In spite of what is often reported about the limitations of local government intervention in the energy transition, existing practices do offer some solutions to addressing the prevailing urban vulnerability to energy changes. In this dissertation, although small adjustments to existing practices are not at first seen as immediately comprehensive, these were found to be sufficient to set the foundations for achieving energy autonomy in the long run.

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2003 - 2008	Urban Designer, Turner & Associates Architects, Sydney, Australia
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	Education
2010 - 2014	Doctoral dissertation “Governing Urban Development for Local Energy Autonomy”, Technische Universität Darmstadt
2000 - 2001	Master of Urban Design, University of Sydney, Australia
1997 - 2003	Bachelor of Architecture (Honours 1) & Bachelor of Science in Architecture, University of Sydney, Australia
	Awards
2003	Board of Architects of NSW Prize
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2001	Henry J Cowan Prize in Architectural Science
2000	Marjorie and Lloyd Rees Prize for Urban Design
	Publications
2014	Radzi, A. (2014). Resiliente Bodenseeregion - im Übergang zur Energieautonomie/Resilient Lake Constance region-transitioning to energy autonomy. In P. Droege (Ed.), Regenerative Region (pp.30-75). München: Oekom Verlag.
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2013	Radzi, A., & Droege, P. (2013). Governance Tools for Local Energy Autonomy. In J. Knieling & W.L. Filho (Eds). Climate Change Governance (pp. 227-242). Berlin: Springer.
2011	Radzi, A. (2011). Urban design as climate and energy policy tool: a literature. In P. Droege (Ed.), Dokonara 2010: Dimensions of Sustainable Alpine Development (pp. 48 - 63). Vaduz: Universität Liechtenstein.
2010	Droege, P., Radzi, A., Carlisle, N., & Lechtenböhmer, S. (2010). 100% Renewable Energy and Beyond-for Cities. World Future Council.
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